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THE ROCK CITY OF PETRA.*

By Franklin E. Hoskins, D.D.

The highlands east of the Jordan River are strewn with ruins marking the rise and fall of successive civilizations — Semitic, Greek, Roman, Christian, Mohammedan, and Crusader. These ruins have been preserved for the modern explorer by the tides of nomadic life, which have swept up from the Arabian desert; but at the southern end of this no-man's land, deep in the mountains of Edom, lies one of the strangest, most beautiful, and most enchanting spots upon this earth—the Rock City of Petra. Its story carries us back to the dawn of human history. When Esau parted in anger from Jacob he went into Edom, then called Mount Seir, and after dispossessing the Horites became the progenitor of the Edomites, who remained the enemies of the children of Israel for a thousand years. These Edomites had princes, or kings, ruling in the Rock City while the children of Israel were still in Egyptian bondage. Some of the darkest maledictions of the Old Testament prophets are those aimed at Edom.

A GREAT "SAFE DEPOSIT."

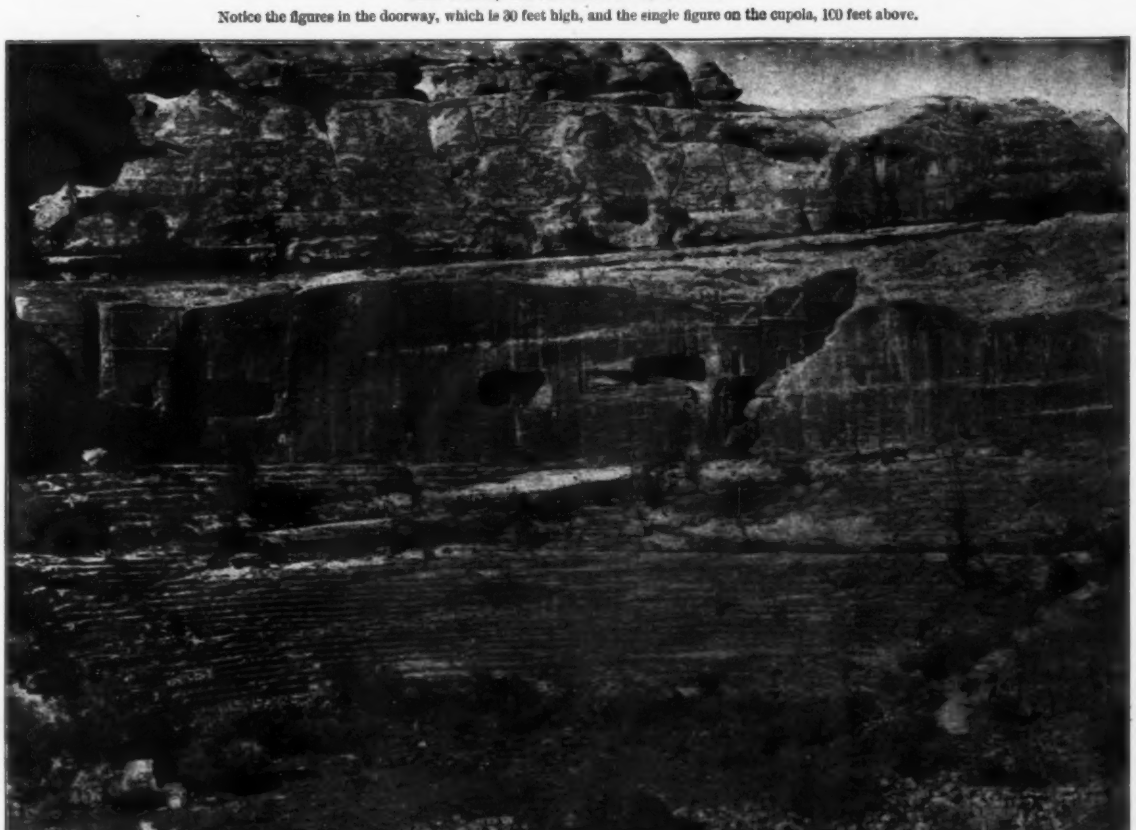
In the days of the Nabatheans, Petra became the central point to which the caravans from the interior of Arabia, Persia, and India came laden with all the precious commodities of the East, and from which those commodities were distributed through Egypt, Palestine, Syria, and all the countries bordering on the Mediterranean, for even Tyre and Sidon derived many of their precious wares and dyes from Petra. It was at that time the Suez of this part of the world, the place where the East and the West met to trade and barter. It was also in fact a great "safe deposit" into which the great caravans poured after the vicissitudes and dangers of the desert. Its wealth became fabulous, and it is not without some good reason that the first rock structure one sees in Petra, guarding the mysterious entrance, is still called "Pharaoh's Treasury." It must have been the Nabatheans who developed the natural beauties of the situation and increased the rock-cut dwellings and temples and tombs to the almost interminable extent in which they are found to-day.

The palmy period of the Nabatheans extended from 150 B. C. to 106 A. D., when the Romans conquered the country and city, extended two Roman roads into it, and established the province of Arabia Petra. The Rock City was always to these regions and peoples what Rome was to the Romans and Jerusalem to the Jews. Horites, Edomites, Nabatheans, and Romans have all rejoiced and boasted in the possession of this unique stronghold and most remarkable city of antiquity.

When Rome's power waned and the fortified camps on the edge of the desert were abandoned, no doubt the soldiers were withdrawn from such cities as Petra. Then the Romanized Nabatheans or Nabatheanized Romans held their own against the desert hordes as long as they could, and went down probably about the same time as the Greek cities of the Decapolis (636 A. D.). From this time onward Petra's history becomes more and more obscure, and for

THE DEIR, OR MONASTERY, PETRA.

Notice the figures in the doorway, which is 30 feet high, and the single figure on the cupola, 100 feet above.



Photos by Libbey and Hoskins in the National Geographic Magazine.

THE ROCK-HEWN THEATER AT PETRA.

Seating 5,000. The seats are rainbow hued, 300 feet in diameter, and 130 feet from floor to top of cutting. Note the figure of a man standing in the amphitheater.

THE ROCK CITY OF PETRA.

*An address to the National Geographic Society, published in the National Geographic Magazine.

more than a thousand years Edom's ancient capital was completely lost to the civilized world. Until its discovery by Burckhardt, in 1812, its site seems to have been unknown except to the wandering Bedouin.

THE SIK OR ENTRANCE DEFILE.

The entrance to the Rock City is the most striking gateway to any city on our planet. It is a narrow rift or defile, bisecting a mountain of many-hued sandstone, winding through the rock as though it was the most plastic of clay. This Sik, or defile, is nearly two miles long. Its general contour is a wide semi-circular swing from the right to the left, with innumerable short bends, having sharp curves and corners in its general course.

The width of the Sik varies from 12 feet at its narrowest point to 35 or 40 feet at other places. Where the gloomy walls actually overhang the roadway and almost shut out the blue ribbon of sky, it seems narrower, and perhaps at many points above the stream the walls do come closer than 12 feet. Photographs of these narrower and darker portions of the defile are impossible. Only where the walls recede and one side catches the sunlight was it possible to secure any views that would reveal the actual beauties of the place. Then no camera could be arranged to take in the whole height of the canyon. The height of the perpendicular side cliffs has been estimated at from 200 to 1,000 feet. Heights, like distances, in this clear desert air are deceptive, but after many tests and observations we are prepared to say that at places they are almost sheer for 300 to 400 feet.

Seen at morning, at midday, or at midnight, the Sik, this matchless entrance to a hidden city, is unquestionably one of the great glories of ancient Petra. Along its cool, gloomy gorge file the caravans of antiquity—from Damascus and the East, from the desert, from Egypt and the heart of Africa. Kings, queens, and conquerors have all marveled at its beauties and its strangeness. Wealth untold went in and out of it for centuries, and now for over thirteen hundred years it has been silent and deserted.

PHARAOH'S TREASURY.

The first time we picked our way into this matchless defile we wandered on amazed, enchanted, and delighted, not wishing for, not expecting, that anything could be finer than this, when a look ahead warned us that we were approaching some monument worth attention, and suddenly we stepped out of the narrow gorge into the sunlight again. There in front of us, carved in the face of the cliff, half revealed, half concealed in the growing shadows, was one of the largest, most perfect, and most beautiful monuments of antiquity—Pharaoh's Treasury. Almost as perfect as the day it came from beneath the sculptor's chisel, fifteen hundred or two thousand years ago; colored with the natural hues of the brilliant sandstone, which added an indescribable element to the architectural beauty; flanked and surmounted by the cliffs, which had been carved and tinted in turn by the powers of nature; approached by the mysterious defile—it is almost overpowering in its effect.

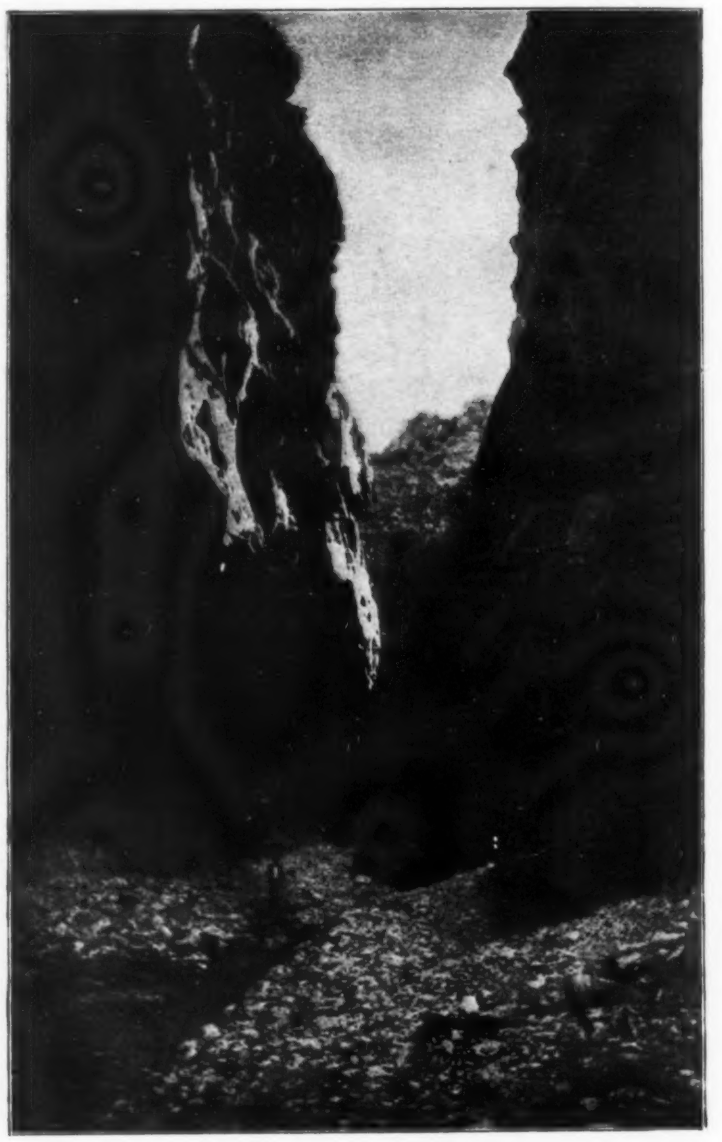
Descriptions of the width and height and the details of this monument of antiquity may enable many to reproduce for themselves some of its striking features; but neither language, measurements, nor pictures can give more than a bald idea of the temple and its charming surroundings. The secret of its magic seems to be the culmination of man's best efforts with the powers and beauties of nature.

Located at the end of a long and difficult journey, whether one comes from the valley of the Euphrates, from Sinai, from Egypt, or from any point of Syria east or west of the Jordan; set in the mountains of mystery, at the gateway of the most original form of entrance to any city on our planet; carved with matchless skill, after the conception of some master mind; gathering the beauties of the stream, the peerless hues of the sandstone, the towering cliffs, the impassable ravine, the brilliant atmosphere, and the fragment of blue sky above—it must have been enduring in its effect upon the human mind. We saw it in its desolation, a thousand years after its owners had fled—tempest, flood, and earthquake having done their worst, aided by the puny hand of the wandering Arab, to mar and disfigure it—and we confess that its impression upon our hearts and memory is deathless.

To portray the marvelous coloring of these masses of sandstone and to give anything like a correct view of this unique feature of Petra is something we attempt with misgivings. From the moment we sighted the great castellated mass in which the city lies hidden until we took our last glimpse from the highlands above, we never ceased to wonder at the indescribable beauties of the purples, the yellows, the crimsons, and the many-hued combinations. Whether seen in the gloom of the Sik, or the brilliant sunshine, that seemed to kindle the craggy, bristling pinnacles into colored flames, they continued to inspire our surprise.

Travelers have vied with each other in their attempts to describe these beauties. After the solid colors of red, purple, blue, black, white, and yellow, the never-ending combinations are best compared with watered silk or the plumage of certain birds.

We shall be listened to if we say with all soberness that "the half was never told" of the effect of this many-hued landscape; for as we saw it glistening with the raindrops after the showers, we saw it before the sunrise, we saw it under the noonday sun, and we noticed, as perhaps no one had done before us, the way in which these ancient sculptors fixed the levels of their tombs and temples and dwellings so as to make most artistic use of the more beautiful strata in the mountain walls, and we marveled again and again, in the never-ending ravines, how these ancient dwellers consciously practised a kind of landscape gardening, where, instead of beautiful effects produced by banks of fading flowers, all was carved from the many-hued and easily wrought solid stone, which took on new beauties as it crumbled away.



Photos by Libbey and Hoskins in the National Geographic Magazine.

PHARAOH'S TREASURY, PETRA.

GORGE OF THE SIK OR ENTRANCE TO PETRA.*

THE ROCK CITY OF PETRA.

THE GREAT THEATER.

Not far from Pharaoh's Treasury is a great theater cut in what may be called the Appian Way of the city. It stands among some of the finest tombs—a theater in the midst of sepulchers. The floor of the stage is 120 feet in diameter. Fully 5,000 spectators could have found comfort in the thirty-three rows of seats. Here also the coloring of the sandstone is brilliant, and at certain places in the excavation the tiers of seats are literally red and purple alternately in the native rock. Shut in on nearly every side, these many-colored seats filled with throngs of brilliantly dressed revelers, the rocks around and above crowded with the less fortunate denizens of the region, what a spectacle in this valley it must have been. What an effect it must have produced upon the weary traveler toiling in from the burning sands of the desert, along the shadows of the marvelous Sik, past the vision of the Treasury, and into the widening gorge that resounded with the shouts of the revelers, in the days of its ancient glory.

The eastern wall of the valley, near the entrance, rises to a height of more than 500 feet. For a length

* Where the rift widens out and makes a sharp bend to the left. Every person and everything entering the city—which numbered several hundred thousand inhabitants—was obliged to pass through this defile, which is nearly 2 miles long. Afterward, when the Romans came, they built two military roads over the mountains down to the city.

of 1,000 feet the face of the cliff is carved and honeycombed with excavations to a height of 300 feet above the floor of the valley.

Here are found some of the most impressive ruins in the city. The Urn tomb in the center has in the rock behind it a room over 60 feet square, whose beautifully colored ceiling can be compared to a great storm in the heavens. The Corinthian tomb and temple are among the largest and most beautifully colored monuments in any of the walls.

The Deir is reached by one of the great ravines up which winds a path and stairway until an elevation of 700 feet is attained. A small plateau opening toward the south gives an extended view of Mount Hor and all the southern end of the Dead Sea cavity. The spot is wholly inaccessible except by the one rocky stairway and winding path.

The Deir is carved from the side of a mountain top, but not protected by any overhanging mass. It is larger than the treasury, but not nearly so fine in coloring or design. It is impressive in its size and its surroundings, but cannot be called beautiful.

Finally, if you will remember that originally the whole valley, from its beginning at the door of the Sik until its exit among the fissures at the southern end of the Dead Sea, is one huge excavation made by the powers of nature, the torrent and the earthquake; and that the hand of time, the frost, the heat, and the tempest have been busy through the ages cracking, smoothing, chiseling mountain top, deep ravine, and towering cliff into a myriad of fantastic forms, and that the subtler, silent agencies of Nature's alchemy have been adding the most brilliant hues to moldering sandstone strata, you cannot but be charmed and amazed at the result of her handiwork.

Then when you enter the city by the winding valley of the Sik, gaze at the stupendous walls of rock which close the valley and encircle this ancient habitation, and mark how man himself, but an imitator of Nature, has adorned the winding bases of these encircling walls with all the beauty of architecture and art—with temple, tomb and palace, column, portico and pediment—while the mountain summits present Nature in her wildest and most savage forms, the enchantment will be complete, and among the ineffaceable impressions of your soul will be the memories of this silent, beautiful "rose-red city half as old as time."*

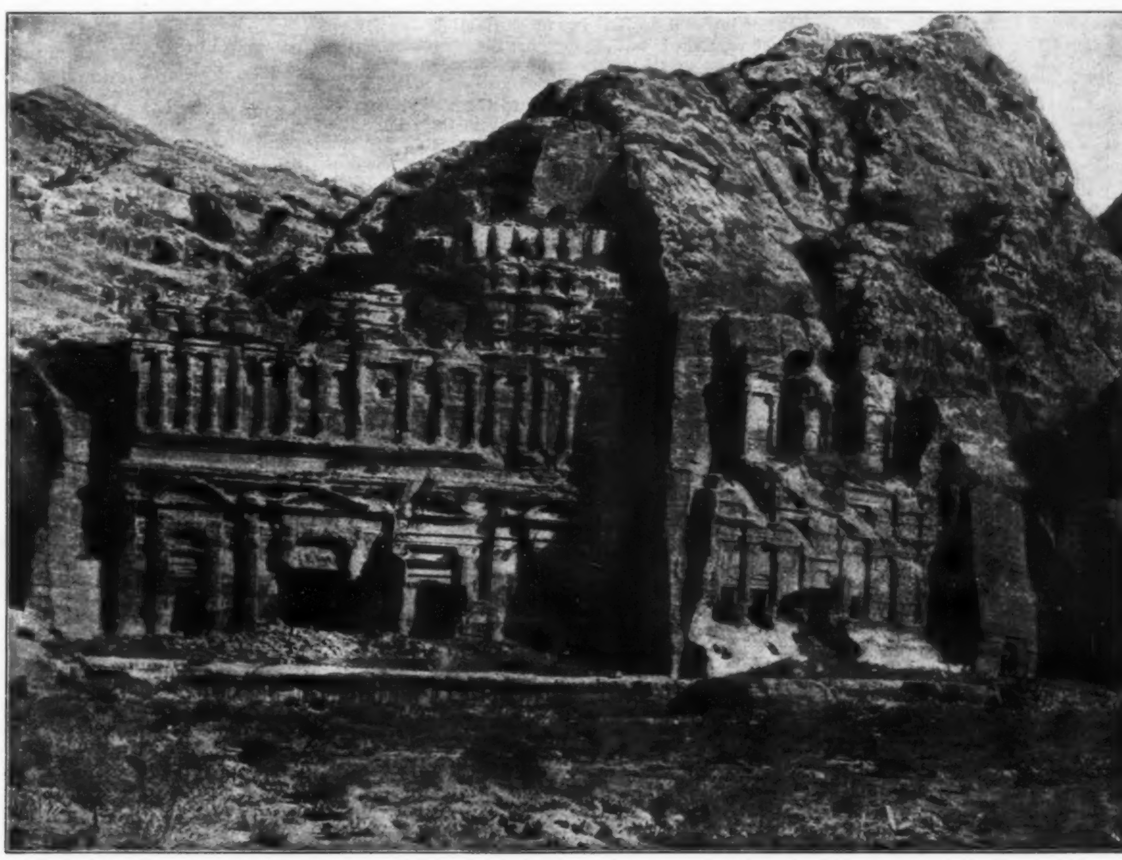


Photo by Libbey and Hoskins in the National Geographic Magazine.

CORINTHIAN TOMB AND TEMPLE.

The finest location in the city and most beautifully colored. Carved out of solid rock, no placed stones or cement or mortar being used.

THE ROCK CITY OF PETRA.

BEES AND FLOWERS.

AN unerring instinct guides bees to the flowers from which the largest crop of honey can be gathered. Some bees are fortunate above others in the possession of very long tongues which can reach the bottom of deep, tubular flowers. Apiculturists endeavor to produce and maintain long-tongued breeds by means of artificial selection and even use a delicate apparatus called the glossometer for measuring the tongues of bees.

Bees are hunting for sugar, and they take it wherever they find it, from flowers, honey, syrup, and even from dry sugar left within their reach by careless housewives or sugar refiners.

In their search they make use of both sight and smell, but judiciously and without being deceived by appearances. It is not easy to lead them astray and they are not attracted by artificial flowers of the most realistic appearance.

Nothing more closely resembles a real flower than its image reflected in a mirror, but Plateau's ingenious experiments have shown that when a mirror is placed near flowers frequented by bees the insects, in general, pay not the slightest attention to the reflected image.

Hence it would appear that the bright color of the corolla plays only a small part in the attraction which flowers exert over honey-gathering insects.

This conclusion is apparently contradicted by certain other experiments, of which the most important were made by Eugen Andreæ and Mme. J. Werg. These investigators placed highly-colored flowers under inverted glass vessels, under bell glasses, and in glass jars covered with panes of glass, and found that bees and other insects gathered about the vessels as if attracted by the sight of the flowers.

Plateau surmised that the bright points of light caused by reflection from convex surfaces of glass had something to do with the effect upon the insects and he devised a series of experiments to decide this question. In order to eliminate the bright points which always appear on convex glass surfaces, especially in direct sunshine, he employed glass vessels of which all the surfaces were plane.

The vessels were rectangular, 10 inches high and 8 inches long and wide. The four panes of glass which formed the sides were cemented together with white gelatine, which was invisible after drying. The top was a pane of glass, simply laid on. In this way the reflection of light by metallic or even wooden edges was avoided. The bottomless glass box was set in a groove in a wooden frame which, in turn, rested on a square board. Long wooden sockets were attached to the bottoms of these boards and stakes fitting these sockets and of lengths varying from 10 inches to 7 feet, which could be driven into the ground, were provided, so that one or more of the glass boxes could be quickly and easily set up at any desired place and height.

All the wooden parts were stained, to resemble old oak, with lampblack and senna mixed with water, no oil, varnish, or other odorous material being employed. The stems of the cut flowers and branches were not placed in water, which would have produced too much vapor, but in moist earth contained in the oldest and dullest clay flower pots that could be obtained.

It was found that the glass box, when thus filled with green leaves, did not attract bees unless it was placed near attractive flowers, visible or hidden, or in a place from which such flowers had been removed.

From numerous experiments Plateau derived the following conclusions:

Insects pay little attention to brightly-colored flowers contained in glass boxes and very few of the insects fly toward the boxes.

The visits of the insects are numerous, however, in either of the following conditions, the second of which was overlooked by previous experimenters:

1. When the boxes of flowers are placed near other attractive flowers of the same or a different species.

2. When the boxes are set in places habitually frequented by the insects.

The box apparently attracts bees when it is set very near attractive flowers or in the place from which they have been cut.

This is proved conclusively by an experiment which is thus described in Plateau's memoir (Bulletin de l'Académie des Sciences de Belgique, 1906, No. 12):

"Two plants of *Althaea rosea* (hollyhock) bearing 18 reddish purple single flowers had been for several days visited by many hymenoptera of the species *Apis mellifica, Megachile ericetorum, Bombus terrestris and B. muscorum.* Close beside these plants and at the height of the flowers I placed a glass box containing green leaves (young apricot shoots) and then covered all the hollyhock flowers with a great cone of brown wrapping paper with a small orifice at the top and a large opening, enveloping the plants at the bottom. The flowers were entirely concealed from every point of view, and were invisible even to insects flying directly over the open top of the cone because of the comparative darkness within. These operations naturally drove the insects away but they soon returned and continued to visit the spot for an hour, or until the termination of the experiment at noon, on a clear and very hot day in July, 1906. The observations may be grouped as follows:

Attempts to enter the box of green leaves by flying against the panes: *Apis mellifica* (honey bee) 4, *Megachile* 1, total 5.

Seeking and fluttering around the box: *Apis* 11, *Bombus* (bumble bee) 7, *Megachile* 1, total 19.

Seeking and finally entering the cone of paper: *Apis* 1 at the upper and 2 at the lower opening, total 3.

Fluttering about the cone of paper without finding entrance: *Apis* 5, *Megachile* 1, *Bombus* 6, total 12.

It appears from Plateau's experiments, therefore, that the color of flowers exerts very little attraction over insects and that the visits of insects to closed glass vessels containing flowers can be explained by defective conditions of experiment.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Cosmos.

The Council of Ministers decided on May 2 to double-track the Siberian railway. The double tracking of the railway has been under consideration for years and the project has been resolved upon and formally abandoned more than once. The plan now is understood to be to double the entire road to the Manchurian frontier, except at Lake Baikal, where increased ferry service is to be provided equivalent to a double track around the lake. The first section to be double-tracked is that between Atchinsk and Irkutsk, the cost of which work is estimated at $21,480,000. Political convicts are to be the laborers.

* For further information on this remarkable city the reader is referred to "The Jordan Valley and Petra," By William Libbey, Sc.D., and Franklin E. Hoskins, D.D. Two volumes. Vol. I., xv. and 358 pp. and 74 illustrations. Vol. II., viii. and 380 pp. and 85 illustrations, 7 appendices, index and map. G. P. Putnam's Sons, New York, 1905.

COMPRESSION OF STEEL INGOTS BY WIRE DRAWING.*

MOST of the physical defects in steel have their source in the process of solidification, which takes place in the ingot mold where the molten steel is allowed to cool into solid form before forging or rolling. In the cooling process the metal is affected by three injurious forces—contraction, crystallization, and liquation or segregation. Many attempts have been made to overcome these injurious effects by using various forms

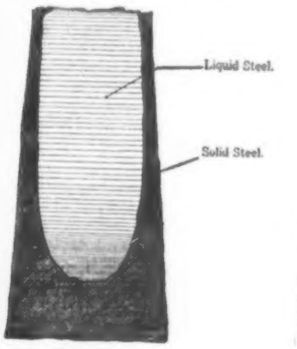


FIG. 1.

FIG. 2.

and materials in making ingot molds, by subjecting the solidifying ingots to compression by the Whitworth system and by other methods of subjecting the ingot to mechanical work. Of these the Whitworth system of compression during solidification has been, until recently, on the whole, the most satisfactory. At the steel works of St. Etienne in France a new process, known as the Harmet process, has recently been tried with remarkable results. Briefly, it consists of compressing the ingot during solidification by wire drawing. A tapered ingot mold is used, smaller at the top than at the bottom, and an hydraulic plunger, forming the bottom of the ingot mold, is forced upward, compressing and solidifying steel into the contracted volume at the top of the mold.

In order to clearly understand the principle of the Harmet process it is necessary to briefly explain the center, as shown in Fig. 1. Almost instantly this shell shrinks and separates from immediate contact with the walls of the mold. Little by little during cooling the liquid mass in the center becomes plastic and attaches itself progressively to the thin shell first formed, adding to its thickness. In the interior is left a hollow corresponding to the volume of shrinkage. If the ingot after cooling is divided through its vertical axis (see Fig. 2) a large cavity is found in the upper part, due to the metal flowing downward by its own weight to fill up the hollows left in the lower part due to shrinkage. Besides this, a hollow space is formed in the center itself after solidification, on account of the failure of the supply of liquid metal to fill the new cavities. These defects or "pipes" are usually visible to the naked eye throughout the whole of the upper half of the ingot, and under the microscope they can often be seen in the lower half. The steel in cooling, after solidification, contracts within itself and produces stresses and oftentimes small cracks and fissures, which it is impossible to detect with the naked eye. Proper subsequent reheating and working, however, almost entirely remove these defects.

The steel in solidifying crystallizes throughout its mass. These crystals have little cohesion between themselves, and when stresses, due to contraction within the metal, are set up, they offer low resistance and cracking occurs easily. The crystallization of the steel is promoted by any cause tending to delay the solidification, such as lining the upper part of the mold with refractory material, and also by the contraction of the ingot which separates from the cold wall of the mold. Except for the possibility of the development of internal cracks, due to contraction, the formation of crystals is not serious, for the structure of the steel can be much improved by subsequent annealing and forging processes.

The metalloids which enter into the composition of steel have a tendency to separate from the iron. The carbon is the most mobile, being attracted in turn toward the main fluid part of the mass, finally concentrating where solidification last takes place, that is, in the head of the ingot. Chemical analysis of an ordinary ingot will show from 10 to 20 per cent more carbon in the head of the ingot than in the bottom and corresponding higher percentages of sulphur and phosphorus.

The combination of these three defects results in the

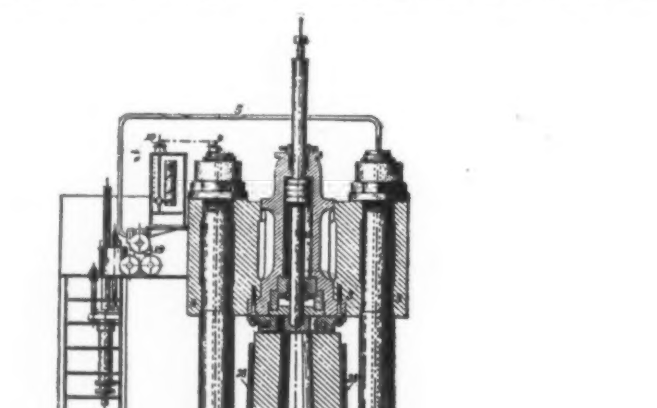


FIG. 3.—SECTION THROUGH HARMET INGOT WIRE DRAWING MACHINE.

action of the liquid steel in solidifying, when poured into the ordinary ingot mold. The steel, at a temperature of about 2,000 deg., comes in contact with the cold walls of the mold, and immediately solidifies in a thin shell containing a mass of liquid steel in the

fact that a steel, although absolutely perfect in the liquid state as regards chemical composition and quality, is, after cooling in the ingot mold, permeated with defects; the upper portion is affected with pipe, the whole mass is crystallized and seamed with cracks and torn by internal stresses, while the chemical composition is rendered irregular by segregation. The metal, in this state, is commercially useless, and mechanical treatment by rolling or forging must be relied on to correct, as far as possible, the defects which were allowed to occur during solidification. The upper end must be cropped, the cracks and fissures have to be rewelded, the internal stresses relieved, and the crystallization broken up and reduced; the segregation, however, remains unaltered, and defects due to this cause can only be discovered later in tests on specimens taken after finishing the material.

The Whitworth process consists of compressing with a static pressure acting on the top of the ingot. In spite of the great pressure applied, the effect of it

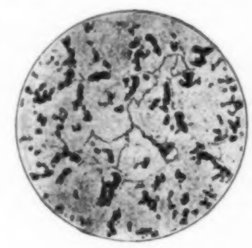


FIG. 4.
NON-COMPRESSED METAL (FISSURED).

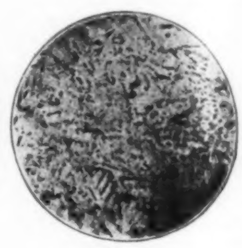


FIG. 5.
COMPRESSED METAL.

extends only to the exterior of the ingot, which in cooling rapidly forms a crust with the rigidity of a column and thus arrests the force applied, and protects the whole of the central part against the pressure from above. The Harmet process, as developed at St. Etienne, is designed, not so much to remedy the defects developed in the ingot as to forestall their development. We have seen that the formation of the pipe is due to the fact that the outer shell of the ingot is permanently fixed, and the subsequent shrinkage of the central mass, therefore, leaves hollows in the center. If this external shell is forced inward on the central mass, and compelled to follow the shrinkage movement or even to close in at a rate somewhat quicker than that at which the volume diminishes, the formation of cavities and internal faults will be avoided. This is exactly the result attained by compression by wire drawing. The compression of the steel is applied to the whole surface of the ingot diminishing its volume by closing in all sides but the top on the central mass.

The defects, due to the formation of coarse crystals and to segregation, are due to retardation in cooling. Instantaneous solidification is, of course, impossible, and these defects cannot be completely overcome, but with the wire drawing process they can be greatly diminished for the following reasons:

(a) The ingot mold is a large mass of metal which rapidly absorbs a quantity of heat, and it is kept in constant contact with the solidifying ingot by the gradual advancement of the ingot under pressure from below.

(b) Steel contracts in passing into the solid state and pressure hastens the transition. This results in shortening the time of solidification and reduces the crystallization.

(c) Segregation is reduced because of the fact that as pressure is applied to the ingot from below the metal is forced upward and comes in contact with the comparatively cool upper part of the mold. This tends to rapidly cool the top of the ingot and prevents segregation.

Fig. 3 shows the hydraulic compressing machine installed in the steel works at St. Etienne. The machine asserts a pressure of 1,200 tons and is suitable for compressing ingots weighing from five to six tons. It consists essentially of an upper head carrying the stripping cylinder and piston, and a lower head carrying the forging ram, the two being tied together with four large tie bolts. The car for carrying the ingot mold is made of cast iron, and in the center is a movable plug which forms the bottom of the ingot mold. The car is run over the bottom head and securely locked in position when ready for compressing. The ingot mold is of cast iron bound with hoops. The inner walls are straight at the bottom for about one-fourth of the height, and from there up are given a taper of 1 in 30. The upper end of the hydraulic plunger is made spherical so as to prevent the movable plug in the ingot car, which is being forced up through the mold, from tilting to one side. When the car with the mold containing the liquid steel is brought under the press, pressure is applied to the hydraulic ram, and the plug, forming the bottom of the mold, is gradually forced up into the mold. The rate of advance is slightly more rapid than the contraction of the cooling steel in order to compress the core of the ingot, but care is exercised not to allow the metal to flow over the top edge of the mold. The rate of advance of the plunger depends on the characteristics of the steel which is being handled, and is in practice determined experimentally by removing the stripping plunger and mounting a mirror at an angle of 45 deg. above the top of the ingot mold, so that the condition of the surface at the top of the ingot can be observed. The rate of advance is adjusted so as to keep the metal just even with the top of the mold, but not allowing it to overflow. This rate of advance is determined experimentally and recorded by an automatic device attached to the machine which registers the curve of plunger displacement; in subsequent workings the plunger is made to advance at a speed corresponding to the experimental curve obtained, the operator manipulating the pressure valve in such a way as to cause the indi-

* An abstract of an article printed in the Journal of the United States Artillery, March, 1905, prepared from data furnished by Major E. L. Zalinski, U. S. A., retired.

cator to exactly follow the curve already determined. The time required for compressing ingots varies with the size of the ingot. Small ingots, weighing about 120 kilogrammes, require at least eight minutes, and this time should be lengthened for best results to 10 minutes. Experiments showed that at the end of five or six minutes the metal was still pasty in the center, and that if the compression was stopped at that point small cavities would still be left in the center of the ingot. At the end of eight minutes solidification is complete, and if the ingot was taken to the mill immediately on leaving the press and there treated physically it would give a perfect metal. However, if it is allowed to cool further after eight minutes of compression the ingot remains solid, but severe internal stresses are set up by subsequent shrinkage. At the end of ten minutes absolute soundness in metal is assured, but even then it is preferable to work the ingot immediately on leaving the press and before it is allowed to cool further.

The results obtained from the process may be considered under two heads, commercial and scientific. It is claimed that the cost of the process is not much greater than that of the ordinary processes, and that the saving in crop ends from ingots is more than sufficient to make up for the slightly increased cost of compression. The French government specifies that uncompressed steel ingots shall have the top 28 per cent cropped, but accepts ingots made by the Harmet process with 5 per cent crop ends, a saving of 23 per cent. The process not only eliminates the defects due to contraction but effects a forging of the metal in the ingot, thus reducing the subsequent work in the rolling mill or under the hammer. Test pieces cut from compressed ingots without forging or rolling showed as good results under tensile and impact tests as test pieces cut from compressed ingots of the same composition which had been forged with a reduction of two times in the cross sectional area.

The physical results from the process are even more remarkable. The compression extends throughout the whole mass and gives a sound metal thoroughly homogeneous in the very center of the ingot. There is a marked diminution of segregation, the chemical analyses at the top and bottom of the ingot being substantially the same. The compressed ingot has a grain of a visibly finer structure and the large cleavages, often found in sections cut from uncompressed ingots, are not found. The photographs reproduced herewith show the relative structure of the compressed and uncompressed ingots. The minute cracks, shown in the uncompressed ingot, constitute a starting point of rupture, and the unexpected failures of steel are often due to such small defects.

The Harmet process is employed commercially on a large scale at the steel works at St. Etienne, and the results obtained are most satisfactory. The compressed metal has been used with success for armor plates, projectiles, crankshafts, etc. The Ordnance Department of the United States army has ordered for test in this country a 10-ton ingot, which will be used in making gun forgings. The process is used at Cammels' in England and Beardmore's Works at Glasgow, where there is an installation for compressing ingots weighing from 20 to 40 tons used in making armor plates; it has also been installed by John Brown & Company. As yet it has nowhere been introduced in the United States.

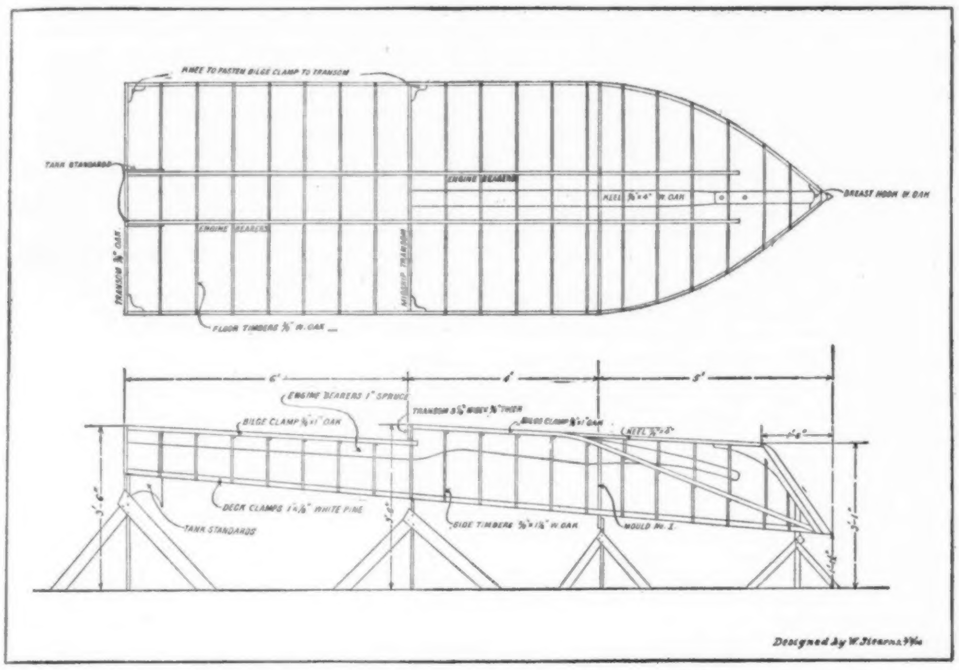
Bengal Matches (Safety Matches) to Ignite Only on a Specially Prepared Surface.—Ignition mass: chlorate of potash, 50 parts by weight; sulphide of antimony, 25 parts; pulverized glass, 10 parts. Friction surface: peroxide of lead, 100 parts; sulphide of antimony, 20 parts; amorphous phosphorus, 5 parts; mixed with solution of gum arabic.

HOW TO BUILD A HYDROPLANE GLIDING BOAT.*

By WILLIAM and WALTER STEARNS.

IN order to build this boat, the frame is first put together, bottom side up. Commence by getting out the stern transom, which is done by taking an oak plank of ¾-inch stock and cutting it to a length of 4 feet 11¼ inches with a width of 12⅜ inches.

This transom is now set up with the top side at a distance of 3 feet 6 inches above the floor. Care must be taken to get this transom level across the top, which is done by placing a spirit level on it and adjusting until it is in the right position.



PLAN AND SIDE VIEWS OF HYDROPLANE BOAT, SHOWING METHOD OF CONSTRUCTION.

This transom should also be plumb, or perpendicular to the horizontal, which may easily be done by placing the level or a plumb bob at the side of the transom and moving it until it is in the right position. The next thing to do is to stretch a center line forward for a distance of 18 feet or so from the middle of the stern transom and at right angles to this transom. After having done this, take a plumb bob, and at a distance of 15 feet from the stern transom on this center line, drop the plumb bob so that the line attached to it will just touch the center line and the point of the bob will not quite touch the floor.

Now take the stem and set it up with stays so that the head of it will be 1 foot 1½ inches above the floor (which is assumed to be level), and at the same time will just touch the line of the plumb bob.

Now measure a distance of 1 foot 6 inches back from this plumb bob line, drop another plumb bob line, and rake the heel of the stem aft until the butt of the stem scarf just comes in line with this last plumb bob line, as will be seen by the dimensions on the construction drawings. Be sure to have the stem plumb, so if a line is dropped from the center line that the point of the bob will touch the center line of the stem at all points; and when it is set up see that the heel of the stem is 3 feet 1 inch above the floor, and that the stem is true to all the dimensions for setting up.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

Next get the midship transom out of ¾-inch oak 4 feet 11¼ inches long and 3⅝ inches wide. This transom is set up 6 feet forward of the aft transom, the top of this being 3 feet 6 inches above the floor or base line.

This transom should be plumbed and leveled the same as the stern transom, and should also have its center directly under the center line.

Get the keel out of ⅞-inch oak, 4 inches wide and 7 feet 6 inches long; and at a distance of 2 feet 2¾ inches aft from the forward end of the keel start and taper it down to 1 inch wide at its forward end. Fasten the forward end of the keel to the stem lap with three ¼-inch galvanized bolts, and fasten the after end to the midship transom, so that the center line of the transom and keel correspond. The keel should be shored up so as to prevent it from sagging in the middle. Now get a mold out according to the dimensions given of mold No. 1 and set this mold up with its aft side 4 feet forward of the aft side of the midship transom, or 10 feet forward of the stern transom. Be sure to plumb and level this mold the same as the transoms.

Also get mold No. 2 out according to dimensions given, and set it up 6 feet forward of the midship transom. Now get two side timbers of ⅝-inch oak, 1½ inches wide and 1 foot 7½ inches long, tapering these timbers down from the heel to the head to 1 inch wide; these are fastened to the sides of the midship transom with screws, and care should be taken to see that they are plumb. The next thing to do is to get the bilge clamps out. These are of oak, ⅝ inch by 1 inch in section, the clamps for the aft plane being 6 feet 1½ inches long. These are fastened to the stern transom with knees, and the forward ends, where they overlap the side timbers of the midship transom should be notched or these side timbers should be let into the bilge clamps and fastened there with brass screws.

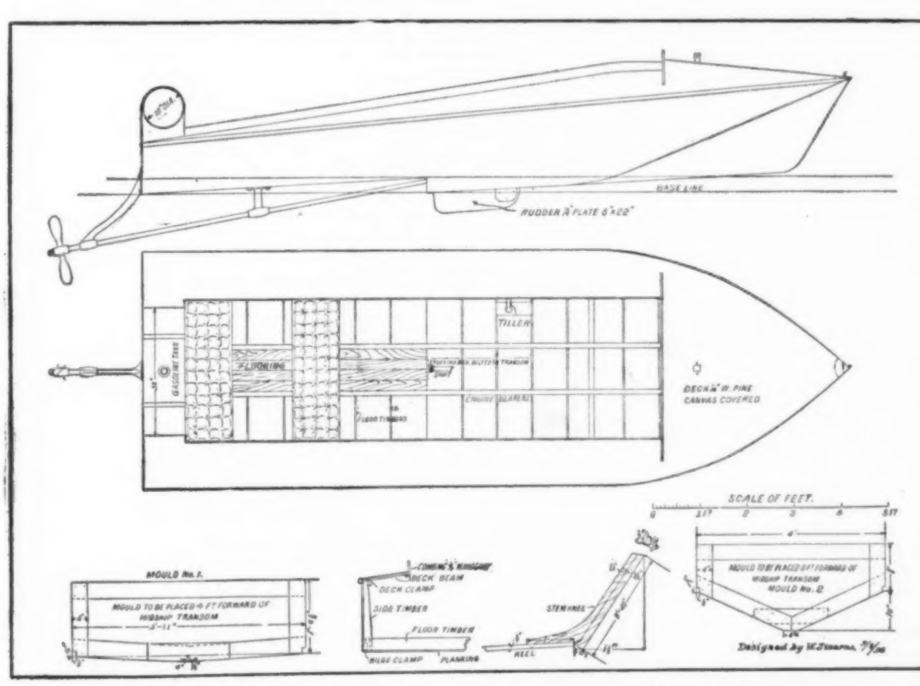
Now get the forward bilge clamps out of ⅝ x 1-inch oak, the aft ends of these clamps being fastened to the midship transom with knees, and being bent around the molds and fastened to the stem with a breast hook of oak.

Next make the deck clamps out of white pine of 1 x ½-inch section and set these clamps 1 inch in from the sides of the molds and transoms, so as to allow for the heads of the side timbers. The deck clamps are fastened at each end with knees. The floor timbers should be gotten out next. These are of ⅞ x 1½-inch oak. Place them on 9-inch centers, and allow them to overhang the bilge clamps, so that a fastening can be driven through them into the bilge clamps.

After having got the floor timbers in, get the side timbers out and fasten them in as the drawing shows, which is done by fastening the heads of the side timbers to the deck clamps with screws and their heels to the bilge clamps with screws, and also by driving a rivet through where the floor and side timbers meet.

Now fit the engine bearers and place them in position, so that when ready for planking you can nail the planking to them.

The boat is now ready to plank. The planking may be of ⅜-inch white cedar as clear as possible and of 7 inches width for the aft plane and sides, while for the forward plane the planking should not be over



SIDE AND PLAN VIEWS OF BOAT AND DIAGRAMS OF MOLDS.

4 inches wide. This planking should be fastened to the timbers with No. 7 1¼-inch brass screws, and to the bilge clamps with No. 7 1-inch brass screws.

The floor timbers should be fastened to the keel by screws 1⅝ inch long, driven from the under side of the keel into the floor timbers.

Where the planking lies on the transoms and bilge

clamps it is best to place cotton batting between, so as to prevent leaks.

After having finished planking, turn the boat over and put the deck timbers in. These are ½ x ½-inch steam bent, and for the bow deck these timbers should have a ridge piece underneath running down the center of the deck the full length, this ridge piece being supported by two wooden stanchions underneath.

The combings are ⅝-inch mahogany, with a quarter-round for filling between the combings and deck.

A half-round oak beading placed where the deck meets the side will act as a rubstrake and will set the boat off. This should be about ¾ inch wide. The decks should be covered with ¼-inch white pine and painted, and after the paint is dry the canvas should be put on, stretched well, and tacked under where the ¼ round and ⅛ round are placed.

The rudder, shaft, hangers, and tank are installed as the drawings show. The interior should be finished as shown with two seats and flooring between the engine bearers.

Fitted with a 5 x 5 two-cycle engine, the original boat of this design has made 21½ miles an hour. With a more powerful four-cycle motor, still better time can probably be made.

DO ANTS SEE?

NEW observations on ants, showing that they do not depend wholly on the sense of smell, as has been asserted, but are principally influenced by the direction of light, as Sir John Lubbock thought, have been made by Mr. C. H. Turner. Some of his experiments are thus described in the Revue Scientifique:

He made a cardboard platform, six inches square, in the middle of an artificial nest; an inclined plane, also of cardboard, enabled the ants to descend from it to the nest. On the platform Mr. Turner placed a large number of workers and grubs. The ants ran to-and-fro, and finally discovered that the inclined plane led to the nest. Then they carried down all the grubs. When the ants and grubs were replaced on the platform the results was the same, the ants having evidently learned the road. Mr. Turner then arranged a second inclined plane, opposite the first, and also leading to the nest. No ant took this plane, but all used the other as before. Then Mr. Turner transferred the planes. . . . What took place when the ants and the grubs were replaced on the platform? The ants took the new plane, in the familiar locations, almost at once. . . . avoiding the old one in its new place. Thus smell could not have been their guide, and the experiment opposes Bethe's hypothesis of a "double-polarized scent" and Wasmann's idea that trails of the ants have for them an "odorous form" that leads them to the nest.

Experiments with marked ants have given results that contradict the current idea that ants always take the same route. The ants learned the road from platform to nest, and also that from nest to platform; the latter took much more time than the former. Sometimes an ant descended by the upper surface of the inclined plane and ascended by the lower surface. Turner has seen an ant descend regularly by the plane and ascend by the central support of the platform. He has seen ants descend by one plane and ascend by the other, but the route from the nest to the plane is not always the same. Other experiments of Mr. Turner have led him to believe that there is much truth in Sir John Lubbock's assertions regarding the rôle played by light in directing the ants. Mr. Turner used the platform as above noted, placing an incandescent electric lamp near the side of the nest toward which the plane descended. When the ants had learned the route a second plane, opposite to the first, was installed. In five minutes no ant had taken the second plane. The lamp was then changed to the opposite side. The ants were evidently troubled, but they very soon adopted the other route. The action of heat in these experiments was excluded by an absorbent screen. On the other hand, the intensity of the light seemed unimportant; lamps of different power were used in turn without affecting the result. The ants react to the direction, not to the intensity of the light.

Mortifer: a Preparation for Destroying Cockroaches and Other Insects.—Boil 3,500 parts by weight of horseradish in water down to a thick pulp and add 30 parts of tartar and 15 of soda; then spread on tin plates and bake in a well-heated oven till the pulp is thoroughly roasted. Grind when cold to a very fine powder in a mill and thoroughly mix with 13,250 parts of powdered sugar, 10,500 parts of powdered borax, and 500 parts of limegreen in a mixing machine. The mixture thus obtained should finally be ground free from dust in the mill and injected into the seams and cracks of the walls of the kitchen and dwelling rooms, floors, ceilings, etc. This preparation will speedily destroy roaches and other vermin attracted by the powerful and permanent perfume of the horseradish.

Fluid for Preserving Anatomical, Zoological, and Botanical Preparations.—5,000 parts by weight of distilled water, 150 parts by weight of alum, 40 parts by weight of salt, 16 parts by weight of niter, 90 parts by weight of sodium bicarbonate, 15 parts by weight of arsenious acid. After filtration add 2,000 parts by weight of glycerine (28 deg. Bé.) and 500 parts of methylic alcohol to 5,000 parts of the fluid. The degree of dilution must be regulated by the volume and sensitiveness of the specimens to be preserved. The fluid has the advantage over alcoholic preservatives that it involves no danger from fire, is devoid of color and smell, has a pronounced antiseptic action, and preserves the softness and color of the specimens, whereas with most alcoholic preparations the latter are liable to become hard.

THE DANGERS OF DENATURED ALCOHOL.

DENATURED alcohol, which, whatever its other virtues or vices, always has been held up as a safe fluid to handle and store, now is branded by an authority as not simply dangerous on account of its explosive properties, but nearly if not quite as hazardous as the gasoline which it is hoped that ultimately it may come to supplant. A. H. Nuckolls, who is responsible for the assertion, is a chemical engineer at the Underwriters' laboratories, and he gives his pronouncement in a contribution to the Quarterly Bulletin of the National Fire Protective Association. Denatured alcohol is not the absorbing topic of discussion it was four months ago; but this question of its inflammability and explosive tendencies as compared with other fuels, and particularly gasoline, is one which cannot well be ignored.

"Denatured alcohol is ordinary alcohol to which has been added an authorized agent in such proportion as to render the mixture unfit for use as a beverage," says Mr. Nuckolls. "It is classed as completely denatured alcohol and specially denatured alcohol. There are two authorized formulæ for completely denatured alcohol. Firstly, 100 parts of volume of ethyl alcohol of not less than 90 per cent strength (180 degrees proof), two parts by volume of approved methyl alcohol, one-half of one part by volume of approved pyridine bases. Secondly, 100 parts by volume of ethyl alcohol of not less than 90 per cent strength, ten parts by volume of approved methyl alcohol, one-half of one part by volume of approved benzine. This latter is the formula generally used. It is the mixture advertised and sold for heating, lighting, power, cleaning, etc. Alcohol denatured in any other manner is classed as specially denatured alcohol, and is used in the various manufactures and arts in cases where completely denatured alcohol would be unsuitable for use.

"No matter what process of denaturing is used it will be seen that the principal ingredient of the mixture is ethyl alcohol. Ethyl alcohol is the ordinary alcohol of commerce, which is made by the fermentation of grain, sugar cane, potatoes, etc. Methyl alcohol is wood alcohol, which is made by heating wood in closed vessels, a process termed destructive distillation. Ethyl and methyl are technical terms indicating the chemical constitution of these alcohols. They refer respectively to two groups of carbon and hydrogen atoms in which the carbon and hydrogen are united very closely in definite proportions. . . .

"Approved methyl alcohol is very impure wood alcohol and must contain at least 15 grammes of acetone and other substances estimated as acetone, to the 100 cubic centimeters. Even pure methyl alcohol is far more hazardous than the ordinary 95 per cent ethyl alcohol, which is the strength generally used for denaturing. The approved wood alcohol, owing to the acetone, is exceedingly dangerous. It gives off inflammable vapors at as low a temperature as the freezing point of water. These vapors are explosive with admixture of air. It must not be lost sight of that ordinary ethyl alcohol is inflammable and explosive. We would not, therefore, expect that the ethyl alcohol will be very effective in rendering the more inflammable and explosive adjunct less dangerous. The addition to this mixture of pyridine bases or benzine in small quantity cannot, to say the least, decrease the hazard.

"As denatured alcohol is a mechanical mixture, no chemical union of the ingredients taking place, they remain as such and hence retain their properties. Owing to the greater rapidity with which they vaporize, the vapors from the mixture will contain a greater proportion of the more inflammable vapor from the adjuncts than the formula would indicate."

Sundry tests of inflammability showing the relative boiling and flash points of various liquids for the sake of comparison, to which the author refers in this connection, show that completely denatured alcohol has a boiling point of 167 deg. F., as against 172 deg. for ethyl alcohol, and 177 deg. for benzine, which stand on either side of it in the table of results. Its flash point, however, is lower than that of the ethyl product, namely 55 as against 61 deg., while benzine flashes anywhere between zero and 32 deg. This would seem to indicate that the denatured product is less hazardous to handle than benzine or other low flashing liquids, as for instance, ether, which vaporizes at 4 deg. The author hastens to explain, however, that the flash point is not the only criterion to be taken into account in judging the relative properties of inflammable liquids from the viewpoint of the danger of accidental combustion.

"In making comparisons of the hazards of liquids it should be borne in mind that because liquids give off inflammable vapors at very low temperatures they are not necessarily more hazardous than liquids which give off inflammable vapors at higher temperatures that are below ordinary temperatures," he says. "In other words, when the flashing point of liquids in question is below ordinary temperatures, the one flashing at the lower temperature is not necessarily more dangerous. In this connection it will be noted that the flashing point of denatured alcohol is below ordinary temperatures. The boiling point is 45 deg. below the boiling point of water, which makes the denatured alcohol used for lighting and heating purposes liable to overheating that may often result in explosions and fires.

"The admixture of the vapors of alcohol with air in certain proportions will explode when ignited. According to Prof. Bunte, of Carlsruhe, admixture of alcohol vapor from 4 per cent to 13 per cent with air is explosive, hence 9.6 is the range of explosibility. According to the same authority, these limits will vary with circumstances, method of ignition, dimensions of the vessel, moisture content, etc. Denatured alcohol, owing to the vapors from the adjuncts, has a wider range of explosibility than alcohol. Explosions outside of the above limits with denatured alcohol were obtained by the writer at a temperature of 61 deg. Fahrenheit. They varied considerably under different conditions. One important fact is that they do not require to be heated. When the proportion of vapor exceeds the explosive limit the mixture is still inflammable with a very wide range—under the conditions of our experiments, up to 50 per cent. The high diffusibility of alcohol is a source of danger. Under ordinary conditions the process goes on slowly and if reasonable care is exercised this hazard is small. It should be noted that wooden and cement vessels do not prevent the dispersion.

"Chemically speaking, our experience with petroleum products has been with very inactive substances, petroleum being made up largely of a series of hydrocarbons which, on account of their lack of affinity, are termed paraffines. In the case of alcohol we have a very different substance in this respect. Careless admixture of certain chemicals with alcohol is liable to result disastrously. The admixture with concentrated acids generally, potassium and sodium, is attendant with violent reactions and the production of dangerous products which may be ignited from the heat generated by the reaction. On the other hand the ready solubility of alcohol in water makes possible the use of water to extinguish alcohol fires, which is an advantage over gasoline. . . .

"It is desirable to find a place for completely denatured alcohol in the scale of hazards of other substances. In view of its inflammability, low boiling point, high diffusibility, liability to leak, and explosiveness, we cannot concede any practical difference in the hazard of completely denatured alcohol and that of gasoline except in one respect—it is not as explosive. A word of caution is in place, that the advantage of denatured alcohol in this respect be not overrated. For there should be no misunderstanding the fact that denatured alcohol is explosive. In the absence of a broad field of experience, if we place ether on a scale of 100 after the manner of Von Schwartz, acetone 97, gasoline 96-87, alcohol, 92-93, completely denatured alcohol 95, we get a view of the relative hazard. There is, therefore, no question but that stringent regulations are called for in the case of denatured alcohol. Broadly speaking, all those precautions used for gasoline should be employed in this case."—Bicycling World.

NOTES ON PREPARING SODIUM SULPHITE.*

By RANDOLPH BOLLING.

THE most convenient laboratory method for preparing this salt absolutely chemically pure and free from sulphate and either anhydrous or crystals with perfect success, is the one based on the decomposition of sulphuric acid with copper, with the liberation of anhydrous sulphurous acid gas. This gas is washed, after leaving the generator, by water to free it from sulphuric acid and copper sulphate spray, and is then allowed to act on a saturated solution of sodium carbonate, with the production of sodium sulphite and carbonic anhydride. The reaction taking place, viz.:

First reaction:	$2H_2SO_4 + Cu = CuSO_4 + SO_2 + 2H_2O.$
Molecular weights:	196 + 63 = 159 + 64 + 36.
Second reaction:	$SO_2 + Na_2CO_3 = Na_2SO_3 + CO_2.$
Molecular weights:	64 + 106 = 126 + 44.

It is thus shown that starting with 196 parts of sulphuric acid and 63 parts of copper in first reaction, we obtain 64 parts of anhydrous sulphurous acid together with the by-products copper sulphate and water. In the second reaction the 64 parts of sulphurous acid formed react on 106 parts of sodium carbonate, producing 126 parts of anhydrous sulphite.

The operations can be carried out easily by using a 1-liter glass flask, Jena glass preferably, and fitting the neck with a two-hole rubber stopper, through which pass a glass delivery tube ½ inch in diameter and a 120-cubic-centimeter stopcock funnel. The flask is charged with 189 grammes of copper scrap (wire or clippings) and is supported by an iron tripod and wire gauze over a large Bunsen burner. The delivery tube is so bent that it passes to the bottom of a Woulff three-neck gas-washing bottle. The second neck contains a straight tube, which prevents the wash water striking back to the boiling acid, in case of any accident, and the third neck carries a delivery tube to a tall beaker 900 cubic centimeters, containing a cold saturated solution of sodium carbonate. The entire apparatus uses rubber stoppers and connectors and ½-inch glass tubing, 1-liter boiling flask, ½-liter Woulff bottle, 900-cubic-centimeter beaker, and one burner, together with gauze and supports.

To start the apparatus, 588 grammes of strong sulphuric acid are poured into the generating flask upon the copper through the stopcock funnel, the Bunsen burner lighted, and the flask brought to a strong boil. The wash bottle in the meantime being filled half full of cold water and the beaker filled with 600 cubic centimeters of water and 318 grammes of anhydrous sodium carbonate added with stirring. At a high temperature a brisk evolution of gas will start and bubble

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

through the gas washer and into the strong soda solution. After the action starts, turn the Bunsen down low in order to prevent foaming of the boiling sulphuric acid. Sulphurous acid gas will be disengaged rapidly, and will at first be instantly absorbed by the soda with a brisk effervescence of carbonic acid, but after twenty minutes or so crystals of sodium sulphite will begin to appear floating in the soda. Finally a large mass of beautiful sulphite crystals will form in the beaker, and the mass begin to get pasty. At this point the end of the reaction is quickly told by the pungent odor of sulphurous acid gas escaping in big bubbles from the beaker. The generator will begin to slack up, so that the Bunsen can be turned off. The mixture of crystals and saturated sodium sulphite can be evaporated down to get the mass solid, and broken up in a mortar, or it can be exposed on sheets of glass in a hot room for producing anhydrous sulphite, as the salt is efflorescent.

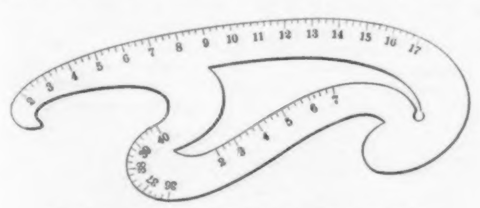
The sulphite can then be packed in glass bottles and the stoppers sealed with melted paraffine wax. The apparatus can be used again any number of times, it being only necessary to fill the flask after it cools down with water, in order to dissolve the anhydrous copper sulphate, and wash it clean. If it is desired to keep the sulphite in saturated solution, a larger beaker for the soda can be used with a larger volume of water, in which case no sulphite will crystallize out; the strength of solution having been determined by hydrometer, and from its specific gravity, the per cent of anhydrous salt calculated. The manipulation in this process is of no special difficulty. The process is also cheap, because commercial acid and copper scrap can be used, and sodium carbonate is also an inexpensive article.

Chemical analyses made on several lots that I made gave 99.56 per cent Na_2SO_3 in the anhydrous salt.

Photographers can use this process for making sulphite for developer, etc., and from the high degree of purity obtained it will be found valuable.

GRADUATED CURVE FOR DRAWING SYMMETRICAL LINES.

MANY curves drawn by means of the so-called French curve, such as the ellipse, hyperbola and parabola, require that the same parts of the French curve are used on each side of the axis of symmetry. The regularity of the curve and the degree of perfection of the symmetry will then depend on one's ability to reproduce in proper sequence on one side of the curve the parts of the French curve used in drawing the other side first. The cut shows a curve graduated on its edges with some arbitrary divisions, say, in eighths. At every fourth one of these divisions a number is placed, starting with one at any convenient point on the curve, and increasing by one until the graduations come back to the starting point. If the curve is made of celluloid the figures may be put on in black, so that when the curve is turned over with the figures down, they can be seen readily. If the curve is made of an opaque substance the numbers must be put on both sides. The numbers on the back should exactly coincide with the numbers on the face, and should proceed around the curve in the same order. In the cut the graduations are not shown all around the edges of the curve, but in graduating a curve they should, of course, be carried all around.—Browning's Industrial Magazine.



DRAFTSMAN'S GRADUATED CURVE.

POPULAR ERRORS REGARDING MUSHROOMS.

THE distinctions between edible and poisonous mushrooms are usually based on empirical grounds, with the result that mistakes of a serious nature may, and often do, occur. The subject has recently received the attention of Prof. Labesse, who has described in l'Anjou Medical the characters whereby edible and poisonous mushrooms are distinguished in various localities. Many popular tests for determining the wholesomeness or otherwise of a mushroom are based on color, odor, taste, and texture; on the presence of rose-colored lamellæ or a milky juice; on the situation in which the fungi grow; and on the action of the mushrooms on various substances, including gold and silver coins, milk, and onions. Thus, according to one popular notion, mushrooms having a blue, violet, green, or red color are unfit for food, but this test would exclude many wholesome fungi, including the green Russula and the green Clytocybe. It has been said that only mushrooms which do not change color when cut are good to eat, but *Lactarius deliciosus*, some species of Boletus, and many other mushrooms which change color, are perfectly harmless; while, on the other hand, *Amanita muscaria* and some other fungi which do not change color when cut should be avoided. Prof. Labesse points out that the presence of an agreeable odor is not an infallible test of a good mushroom, as a species of Amanita (*l'Amanite phalloïde*) is especially dangerous in spite of its pleasant odor. There is a dictum among certain amateur gatherers that a good mushroom has a grateful taste. This test is useful in many cases, but not in all—e. g., l'Amanite phalloïde and la Fausse Oronge (*Amanita muscaria*) are scarcely bitter, but quite unfit for eating.

As regards texture, it is generally considered that compact, brittle mushrooms, with a dry skin, are edible, but Prof. Labesse considers this to be a mere prejudice, as the eating of certain species of Russula would seriously indispose any one placing confidence in these characters. Mushrooms with rose-colored lamellæ are usually considered to be edible, but this is a false notion, some species of Volvaria and other poisonous fungi possessing this character. Mushrooms with a milky juice are regarded as dangerous by some collectors, but this rule must not be followed too literally, as many excellent members of the genus Lactarius would thereby be excluded. The situation in which mushrooms grow is a very uncertain criterion of edibility. Thus, it would be dangerous to regard all mushrooms growing in meadows, open fields, and roadsides as good, since many suspected kinds grow in such places. On the other hand, mushrooms growing in coniferous woods and under trees generally have been condemned, but the succulent *Lactarius deliciosus* grows in coniferous woods, and the edible Pholiota grows under poplars, while species of Helvella and Hydrum, which flourish in shady woods, form a wholesome dish. The blackening of a gold or silver coin or ring does not prove a mushroom to be poisonous; the blackening is generally due to more or less decay in the mushroom, as fresh mushrooms, whether poisonous or not, fail to blacken these metals. The curdling of milk by mushrooms is another property which has nothing in common with toxicity, the cause of the curdling being attributable to the presence of an acid or a ferment. An old custom consisted in dipping a white onion or a clove of garlic into the cooking vessel containing the mushrooms, and noting whether the latter turned brown or not; the presumption that only noxious mushrooms are turned brown by this treatment is not justifiable, since some non-poisonous varieties do change color in this way, while some poisonous varieties do not. It is a common belief that slugs and insects attack edible mushrooms, but this is by no means universally true, as the deadly Amanitas are attacked by slugs, while many wholesome fungi are respected by these depredators.

The tests, so far described, are largely of a rule-of-thumb nature, but another test which has received wide acceptance, depends upon the fact that many poisonous fungi are surrounded by a *velum universale*, notable examples being the intensely poisonous subgenera Volvaria and Amanita and the puffballs. But, like all other rules, this is open to exceptions, including the genus Agaricus, to which the common mushroom, *A. capestris*, belongs. Prof. Labesse considers that there are no practical empirical means by which amateurs may, with confidence, decide whether an unknown fungus is good to eat. There is often a risk taken in eating mushrooms, and those who do not wish to incur the risk are reminded by Prof. Labesse of the method adopted by Gerard, in 1850. He boiled the mushrooms for some time in salt water, threw away the water, and exposed the mushrooms to the air. He fed his family for nearly a month upon all kinds of poisonous mushrooms treated in this way, and found them to be nutritious, though less palatable than mushrooms cooked in the ordinary way. Prof. Labesse suggests that not more than one mushroom in ten is poisonous, and that the best test consists in rejecting those which have a ring at the base of the stipe. Deadly mushrooms, as a rule, possess a ring or annulus consisting of the remains of the *velum partiale*, which covers the young mushroom and is fractured during growth. In order to apply this test the mushrooms must be gathered with care. Unfortunately, in rejecting mushrooms possessing this character some excellent varieties are rejected in addition to the commonest poisonous varieties. Amateurs should know the characters of the mushrooms which grow in their neighborhood, restrict themselves to certain kinds which they know to be edible, and in cases of doubt should abstain altogether.—Lancet.

EATING WITH OUR EYES.*

By DAY ALLEN WILLEY.

WHEN Johnny Smith gets up in the class and the teacher asks him to "define the senses," he twists and untwists his fingers a few times behind his back. Then it comes to him. "Seeing, smelling, hearing, feeling, tasting." Ask the fruit-grower and the marketman, however, and they will tell you that the tongue doesn't count for much nowadays when it comes to getting things to eat. In short, according to what they say, we tell more about food by looking at it than by tasting it. Appearance is preferred to flavor.

The man who wants to know how rapidly we are apparently losing the sense of taste need only visit a corner fruit-stall when business is brisk. As apples form one of the staples just watch the apple-buyers. Nine out of ten will "put their money on the red" and will pay a cent more for a glossy than a dull-tinted apple. Next to it may be a greening, which is firmer in flesh, juicier, and of a far finer flavor—but it doesn't look as pretty as its red neighbor, and though the latter may be mushy inside and flat-tasting it has the preference. The buyer probably does not know that the polish is sometimes put on the apple, by dipping it in the water for rinsing lemonade-glasses and rubbing it with the vendor's dish-rag—but that's one of the tricks of the trade.

* From American Homes and Gardens. Published by Munn & Co.

At the same stand the housewife pays five cents apiece for unripe oranges, so sour that you couldn't eat one filled with sugar. Delicious ripe ones, just as large, go at two and three cents. Why? Because the yellow oranges appear so attractive that the lady wants them on the table—not to eat, but for ornament. It is a fact that carloads of "yellows" are shipped to New York from California every winter because they sell at a higher price than eatable fruit—just to look at.

That is why at the country fair the judges of the fruit give out the blue ribbon by what they call the "score." Each score is made up of a hundred "points" or credit-marks—so many for shape, so many for color, etc. Now in the case of the apple, one which has a skin free from all bruises or other blemishes gets twenty points on the score-card; but its flavor—its actual eating quality—counts for fifteen—only as much as its form and size. It may have a delicious flavor, far more palatable than the one with the fairer skin, but the other gets the ribbon because it is more pleasing to the eye. Go through "Domestic Hall" and you will see the butter and cheese judged in the same way. Sometimes the judges cut off a bit and put it in their mouths, but the kind that looks nice and is done up in an attractive package often gets the prize, though its flavor may not be up to some which is a little "off color." So it is that butter and cheese often get their rich golden tint by patent colors, which are sold at the "Corners" grocery in packages just like seeds or tacks. One concern in the United States has made so much money out of "butter-color" in the last few years that some of its stockholders have started a magazine—which shows how rich they must be.

Take such fruits as blackberries and strawberries. The countryman will cull out the little ones on the bushes every time, if he is picking for his own table, because he knows they are sweeter and richer in flavor than the larger, which have lost in quality as they increased in size. These he picks for market because he can get twice as much for them from his commission merchant. He also ships him every red apple in the orchard—windfalls and all—and keeps the juicier and really finer fruit for the cellar-barrel where he has his winter supply. You can always tell a farmer in the crowd around a fruit-stand, for he skips the shiny, showy part of it and looks for the paler or striped apples. They cost less and "eat" better.

It seems strange that nuts sell largely according to their appearance, but it is a fact that if pecans or any smooth-coated nuts are polished so the shells glisten, they are actually worth about one-fifth more than if the shell is left in its ordinary condition, though the polishing does not affect the food properties one iota. Peanut "factories" in the South are operated solely to clean the shell of this nut and make it look more attractive. Hard-shell almonds sell for about half as much as "soft-shell"—merely because the latter have a little thinner coating and you can crack them with the fingers. This, however, is more of an appeal to the sense of feeling than to the eye, but the rice industry is one of the most remarkable examples of this fascination for the things that look good. The outside portion of a rice-kernel is its most healthful and nutritious part. It contains absolutely nothing which is injurious—but it has a dull appearance. So nearly all of the rice which is eaten in the United States—outside of the Southern States—is "milled." The outside is rubbed off by machinery to give the kernel a glistening appearance. Merely for this reason millions of dollars have been expended in this country for buildings and machinery that do nothing else but polish the grain. They don't eat the milled rice in the region where it grows because, like the farmer who sends his big berries to market, they know the outside is the best of it. Some kinds of coffee sell for a higher price in the grocery because the berry has been "glazed" or polished. It is put up in boxes with glass sides to tempt prospective customers by its good looks.

A story went the rounds not so long ago that a new kind of hen had been bred which would lay an egg with a handle to it so the cook could turn it into an omelet more easily. In Boston it is a question if they would not prefer a hen which lays only brunette eggs. Produce men save all their brown eggs for this market, as they are worth two or three cents a dozen more than those which have dead-white shells. Perhaps the dark hue is favored because it resembles the baked bean, but there is no doubt that it is given the preference. On the other side of the country the gourmands of San Francisco want white eggs—the whiter the better; so the dealers sometimes "lime" them purposely to lighten the color. In fact, the West favors lighter tints than the East in about everything except chickens. Chicago likes a light-colored butter, and buys glucose with broken bits of wax in it because it resembles white honey. It is the plain truth that dark honey, though perfectly pure, sells at a much lower price in Chicago than the imitation article. On the question of chicken-color, however, we are a unit. Yellow-legged chickens have the first call over any other kind, although the American tourist in France who asks for chicken gets a fowl which is usually colorless. The French chef claims that the yellow-leggers are no plumper or tenderer than the whites, and proves his statement by showing that the yellow does not come from fat under the skin, as some suppose, but from coloring matter in the skin itself.

The Department of Agriculture has been making a study of the curious way in which the eye is taking the place of the tongue in our preference for the things we eat.

THE PROBLEM OF TELEVISION.

Now that the photo-telegraph invented by Prof. Korn is on the eve of being introduced into general practice, we are informed of some similar inventions in the same field, all of which tend to achieve some step toward the solution of the problem of television.

Among the most promising schemes of this kind are doubtless the telegraphoscope and telestereograph invented by Belin, of Nancy. These two apparatus, although strictly different in principle and application, are destined to supplement each other in the same field.

The problem solved by the telegraphoscope is the production of an unalterable image of any illuminated object (person, monument, or landscape) at any desired distance, by a purely physical method, without the aid of photography. While this is actually achieved by the apparatus now constructed, the device is expected some day to solve completely the problem of "television," when these images will be produced with a more rapid succession than that corresponding with the persistence of retina images.

The problem solved by the telestereograph is identical with that solved by Prof. Korn's apparatus, viz., the reproduction at a distance of a photograph located at the transmitting station, by means of another photograph produced at the receiving station. However, the solution suggested by Belin is entirely different in principle from Prof. Korn's scheme.

The telegraphoscope comprises a number of novel processes intended for reproducing the real aerial image of a camera obscura by a purely physical method without the aid of any chemical manipulation. Sensitive plates or papers, as well as developing or fixing processes, are thus dispensed with, the image being immediately recorded on any kind of paper either in the vicinity of the object or at considerable distance, according to the length of line connecting the two stations.

The general principles underlying the construction of the telegraphoscope are as follows:

At the transmitting station there is installed a camera obscura similar to a photographic camera, an objective and a mirror reflecting the optical image on a row of eighty exceedingly small selenium cells. A collector is provided for successively inserting these cells in the same circuit.

The receiving station comprises a highly sensitive galvanometer with a very rapidly oscillating needle (Blondel's oscillograph) and three local circuits, viz.:

1. A circuit containing the most important organ of Belin's scheme, viz., the equilibrator, and a telegraph relay.

2. The primary circuit of a small induction coil, containing in turn the second part of the equilibrator.

3. The secondary circuit of the induction coil, comprising a spark gap, the spark of which, controlled by the distributing collector referred to, perforates a paper with a number of exceedingly small holes, all of which are situated at the same distance from the centers while their diameters are directly or inversely proportional to the corresponding points of the image. These points, situated side by side without covering each other, impart to the reproduction the aspect of an autotypy.

The ratio above referred to can be made at will either direct or inverse (the images of the telegraphoscope becoming positive or negative respectively), simply by handling a current-reversing switch.

It should be understood that the selenium cells used in this apparatus are constructed by the inventor himself, M. Belin having nowhere found a set of eighty identical cells of sufficiently small dimensions (1.5 millimeter). It was only after extensive researches continued for many years that the inventor developed his actual process, according to which the eighty cells are prepared simultaneously on the same support. As these cells show a considerable resistance (5 megohms), the resistance of the circuit becomes negligible in comparison. On the other hand, they are entirely free from inertia, so as to necessitate no compensating device.

Experimenters who have hitherto dealt with the same problem have been unable to obtain at the receiving station a satisfactory effect, either with the slight current intensities traversing the selenium or with the feeble differences in intensity corresponding with the difference in the resistance of the selenium between total darkness and full light in the camera. This difficulty (to which the failure of all previous attempts may be ascribed) is entirely eliminated by the equilibrator. In fact, quite independently of the current intensity at the receiving station, the local current always has a considerable intensity, which is always strictly proportional to the intensity traversing the line in spite of the unceasing variations in the latter, due to the reproduction of half-shades.

This equilibrator was tested as far back as two years ago, when some preliminary experiments were carried out between Paris-Havre-Paris (480 kilometers), the perforations obtained at the receiving station always reproducing faithfully any variations in the luminous intensity of the sending station.

The final apparatus has just been completed at Paris by M. Ducretet, the well-known constructor. After performing some additional regulations, a trial service will be commenced.

As regards the other invention, the telestereograph, this as above mentioned, is intended for telegraphically transmitting a photograph to be reproduced at the receiving station by another photograph. However, the solution suggested by Belin is entirely different from Prof. Korn's scheme.

In opposition to Korn's as well as to all earlier devices of a similar kind, this apparatus in fact dispenses with selenium both at the sending and receiving stations. The apparatus thus is entirely mechanical in construction and independent of such capricious organs as selenium resistances, while electricity as in telegraphy plays no other part than that of controlling the process. At the receiving station the image is reproduced by lines 1/6 millimeter in thickness and in distance, so that the pictures obtained show continuous shades which are very rich in detail. By virtue of the very principle underlying its construction, the drawing is necessarily of good definition.

While the reproductions are normally of the same dimensions as the original photograph, they can at will be made greater or smaller simply by controlling a nut, the same original photograph can be made to give a positive or a negative reproduction with other shades similar to those of the original photograph or with stronger or slighter gradations.

After a slight alteration the same apparatus can be used as a high speed facsimile telegraph without using any special paper for writing the telegram, the only condition being the use of a special ink.

The apparatus is now being constructed by M. J. Richard.

A NOVEL LUMBERING CRANE.*

By Henry Hale.

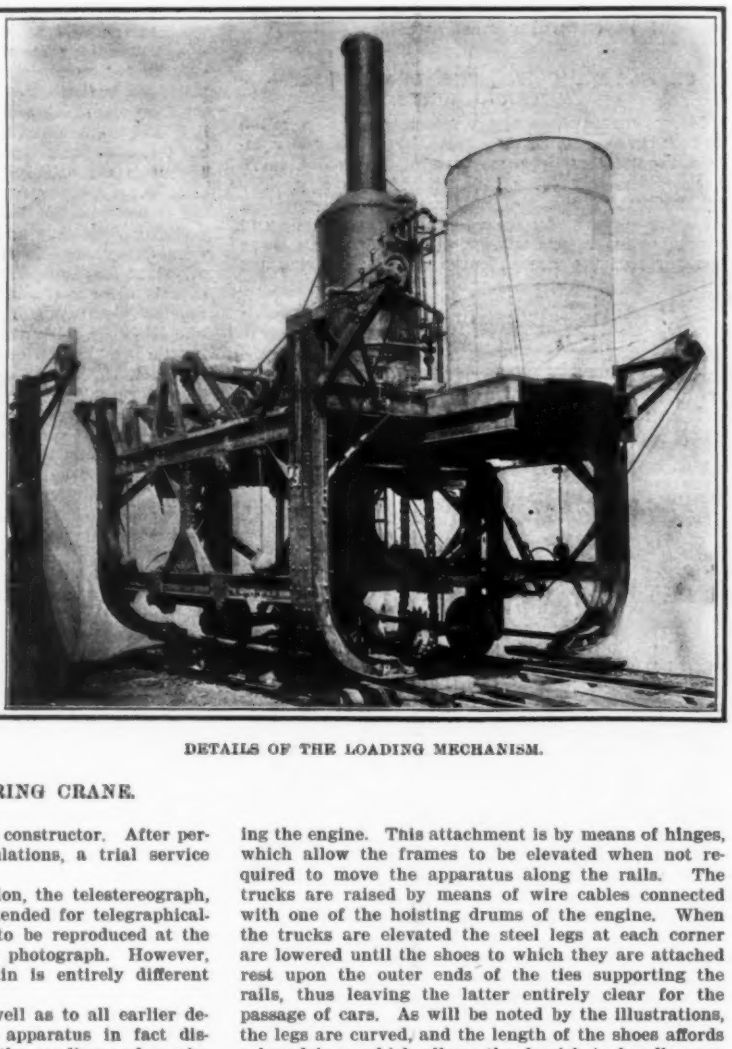
The value of the crane or derrick has been recognized by its employment in a remarkable variety of ways in lifting and transferring material, but its importance in lumbering operations, especially in the forests of the Northwest, is shown by the different devices with which it is combined. One of these is notable not only on account of the power which it develops, but the different purposes for which it can be utilized. While it is termed a log loader, it performs three distinct operations—moving cars from place to place, skidding logs from their beds to the loading point, and piling the logs for transportation. In doing this work it is utilized both as a locomotive and as a stationary engine, and such is its capacity that it will load from 125,000 feet to 150,000 feet of timber in an ordinary working day, although a crew of but four men are usually required to operate all of the apparatus.

The most unique feature of the McGiffert loader, as it is called, is the fact that the trucks on which it is carried when acting as a locomotive are adjustable, so that they can be elevated several feet above the rails when it is desired to use the mechanism in a stationary position. This allows empty flat cars to be run beneath the loader, and facilitates as well as economizes in lumbering operations, as it is not necessary to employ a logging locomotive. The main framework of the loader is composed of steel I beams eight inches in width, held together by channel bars and angles of suitable proportions to withstand the strain required. The truck frames containing the axles are fastened to a shaft attached to the under side of the deck supporting the engine. This attachment is by means of hinges, which allow the frames to be elevated when not required to move the apparatus along the rails. The trucks are raised by means of wire cables connected with one of the hoisting drums of the engine. When the trucks are elevated the steel legs at each corner are lowered until the shoes to which they are attached rest upon the outer ends of the ties supporting the rails, thus leaving the latter entirely clear for the passage of cars. As will be noted by the illustrations, the legs are curved, and the length of the shoes affords a broad base which allows the derrick to handle very heavy weights.

When the loader is being utilized as a motor, the legs and their attachments are lifted above the track. The truck wheels are about the size of those utilized under an ordinary freight car. Attached to the center of each axle is a toothed wheel, around which passes a heavy sprocket chain, leading upward to another axle installed just below the engine deck. To this axle is attached a sprocket chain passing around a shaft directly connected with the engine. In this way sufficient power is produced to propel the loader along the track at the rate of six or seven miles an hour without a load. It will pull or push a train of loaded cars at a rate varying from three to four miles an hour on a level track, as the motive power being transmitted to both axles practically makes all of the wheels driving wheels, giving a pull representing the force of 800 tons.

The derrick, which is of the double or shear type, consists of two legs, which are set into the deck and firmly anchored. The tackle used depends upon the

PLACING THE TOP LOG ON THE PILE.



DETAILS OF THE LOADING MECHANISM.

A NOVEL LUMBERING CRANE.

* Specially prepared for the Scientific American Supplement.

work to be performed, consisting of either a single or double set of blocks for ordinary loading. When a car is to be loaded, the usual method is to grip the log at each end, the boom cable being split in two, and each end of it terminating in a hook. In this way logs 60 feet in length can be lifted by the ends and placed in position guided by but one man, as the end grip prevents them from swinging. The operation illustrated shows the ordinary grip used for handling short logs, which holds them in the center. As the capacity of the derrick is only limited by its height, the loading of a car can be completed mechanically, the logs being raised by winding the cable upon a drum connected with the engine in the usual manner. So rapidly can timber be thus transferred, that 75,000 feet has been actually put on cars in two hours.

In the skidding operation the loader is run along the track to the place where it is desired to pile the logs or to load the trains. The tracks are raised, and it is employed as a stationary engine. The logging cable is attached to a horse, which carries it to the log to be skidded. It is hooked to one end, and the log pulled to the loading point merely by winding the cable upon the drum. Such is the power of the loader, that the largest size trunks put upon standard gage railroad cars can be moved distances from 1,000 to 1,500 feet, although the weight of cable may require two horses to handle it when not loaded. The skidding device is double acting, usually two cables being employed, and while one is being hauled in with its load, the other is being run out for loading. By using two cables a log scaling 2,000 feet timber measure has been hauled a distance of 500 feet and put on the car in fifteen minutes. One advantage of skidding by this method is that where depressions or abrupt rises of ground occur in the track over which the log is to be taken, such is the power of the machine, that usually they can be carried over these inequalities without the necessity for shoring up the log, or using other means to overcome the difficulty.

As already stated, the trucks on which the loader is moved when the engine is utilized as a locomotive can be raised so far above the track that an ordinary flat car can be run under the machine. By means of the boom and cable, cars can be hauled to either end of the loader, and trains "made up" without the assistance of a switching engine. When a car is to be loaded, it is placed directly in front of the loader and under the boom. When the piling has been completed, the propelling trucks are lowered and the loader run back until it is directly in front of the next car. Elevating the trucks and lowering the legs, it is only necessary to extend the cable backward from the booms and underneath the loader, fasten it to the empty car, and pull it forward beneath the booms, when it can be loaded. After a sufficient number of cars have been loaded, the device is again converted into a locomotive, coupled to the nearest car, and moves the train to the mill or to the railway station, where the logging cars are attached to the ordinary locomotive and carried to their destination.

An idea of the capacity of one of these loaders can be gained, when it is stated that in lumbering operations in Louisiana, logs weighing as much as ten tons each have been handled without difficulty, although the total weight of the machine when resting on the drivers is not over three tons for the largest size. The engine usually employed is of the double-cylinder type and equipped with two bronze bush friction drums.

Turbine propulsion for small passenger vessels is being widely adopted in Great Britain. Vickers Sons & Maxim are building a 300-foot boat for the London and Northwestern Railroad Irish service between Holyhead and Dublin with a speed of 20 knots per hour. Messrs. Denny Brothers, of Dumbarton, have recently delivered the fourth turbine passenger vessel to the Southeastern Railroad for their Channel service between Dover and Calais. On the official trials this boat attained a speed of 22.576 knots per hour, which was 1.75 knots in excess of the contracted speed, so that the 21-mile crossing between the English and French ports can be covered in less than the hour. What, however, will be the fastest vessel of this type engaged in this class of passenger traffic is now being built for service between the Isle of Man and the English coast, the speed of which is contracted to be 23 knots per hour.

A NEW AUTOMOBILE AMBULANCE.

By Our ENGLISH CORRESPONDENT.

THE St. Andrew's Ambulance Association of Glasgow has recently secured an interesting type of automobile ambulance for work in the streets. The distinctive feature of this vehicle is the system adopted for warming the interior by means of exhaust gases from the engine. In general appearance the chassis does not differ from the standard vehicle manufactured by the Argyll Motor Company, who constructed this ambulance with one or two special modifications incorporated to render it more suitable to fulfill its special work. The motor is of the vertical, four-cylinder Aster type, developing 26 to 30 horse-power with chain-driven gear pump for the jacket water and an auxiliary fan. The transmission is of the Govan patent type, comprising three speeds forward and one reverse, the rear axle being worm driven. The wheel base is 11 feet with a tread of 5 feet.

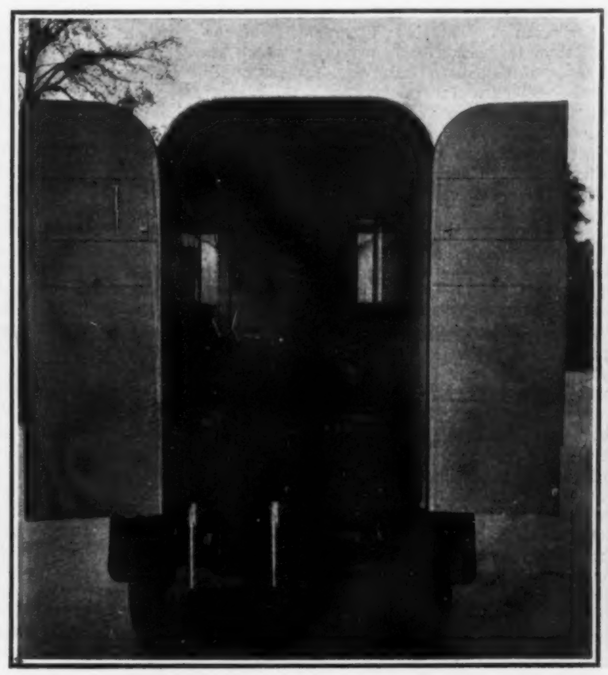
Owing to the necessity of reducing oscillation and vibration to a minimum, special attention has been devoted to the springs of the vehicle. Those in the rear are exceptionally flexible, while those in front form a special duplex arrangement. Owing to the peculiar nature of the Glasgow thoroughfares, and to facilitate the manipulation of the wagon in heavy traffic, a wide lock on the steering wheels is also specially provided.

The internal equipment of the ambulance body, which is 8 feet in length by 3 feet 10 inches width, and 6 feet in height, comprises a couch for the injured on one side, and a seat for the attendants on the other. The interior is lighted by two narrow slot windows in front and three ceiling electric lights, supplied from a secondary battery, while electrical communication is provided between those inside and the driver by means of an indicator on the dashboard. The body is insulated from the chassis by the aid of thick rubber pads, which absorb all shocks.

As already mentioned, the distinctive feature of the vehicle is the method adopted for warming the interior by means of the exhaust gases from the engine. There is a subsidiary pipe fitted along the entire length of the floor and in communication with the main exhaust pipe. The junction is fitted with a bypass valve, by means of which the hot gases can be deflected from the main exhaust pipe after leaving the muffler, and discharged through the subsidiary pipe, radiating warmth through the apartment during the run, and thence into the outer atmosphere. The driver of the vehicle has control over the valve, and can thus regulate the quantity of gas passed through the radiating pipe, so that the internal temperature of the wagon can be completely controlled.

This ambulance has proved eminently successful. It is remarkably silent when running, and owing to the system of springs, it is most comfortable for the injured person. The three gears give a range in speed from 6 to 21 miles per hour at 1,100 revolutions per minute of the motor. By the acceleration of the latter, however, the speed can be increased to a maximum of 28 miles per hour. The novel deflection of the exhaust gases through the interior of the vehicle has proved highly beneficial, especially in severe weather.

AUTOMOBILE AMBULANCE INTERNALLY HEATED BY THE EXHAUST GASES.



INTERIOR OF THE AMBULANCE.

[Continued from SUPPLEMENT No. 1640, page 26274.]

ARTIFICIAL FERTILIZERS: THEIR NATURE AND FUNCTION.—II.*

By A. D. HALL, M.A., Director of the Rothamsted Experimental Station, Lawes Agricultural Trust.

THE SUPPLY OF NITROGEN TO THE PLANT.

IN taking up the detailed study of fertilizers it is natural to begin with those containing nitrogen: not only is it the most important fertilizing element, for it both costs more per pound and returns more to the farmer for his investment than either phosphoric acid or potash, but also it differs from the others in that plants live habitually in contact with a vast unusable store of it. Since plants live in an atmosphere four-fifths of which consists of elementary nitrogen it is perhaps necessary to justify a little the statement made in my first lecture that they only obtain the nitrogen they require in a combined form by means of their roots. The form that the demonstration has taken may be seen in the water culture experiment which has already been illustrated; in the absence of combined nitrogen the development of the plant is very small. The same is true for cultures in sand, which are more comparable with natural conditions, and many experiments have been performed with the greatest care with plants thus growing in artificial soils supplied with a known amount of nitrogen. When the plants have come to the full term of their growth the nitrogen they contain is found to be exactly balanced by the amount of the same element which has been removed from the soil. And if objection be made that such plants are enfeebled by the unnatural conditions, so that they have lost their power to bring nitrogen into combination—to "fix" it, in current language—there are many other types of experiment which render such criticism invalid. For example, Hellriegel performed a long series of experiments with different plants which showed, up to a point, that the amount of growth was very closely proportional to the amount of nitrogen supplied in a combined form when there was a sufficiency of the other elements of plant food present. This would not be the case were the plant able to get any nitrogen for itself from the atmosphere. Again, to meet an early objection of Liebig and his followers, in the Rothamsted experiments upon leafy root crops, which still seemed unable to draw upon the nitrogen of the air though freely supplied with phosphoric acid and potash, to one plot there was supplied a very small amount of active nitrogenous manure, just to give the young plant a good start, whereupon it might be able to continue to feed upon the atmospheric nitrogen. But, as Table VIII. shows, the small addition of nitrogen only produced a small increase of crop, very fairly proportional to the much larger increase produced by a normal application of the same fertilizer. If then the yield of most of our field crops is, within the limits of experimental error, proportional to the amount of combined nitrogen they receive, it is necessary to conclude that they have drawn none from the atmosphere. The tenacity with which in the face of such evidence the opinion has been held that the leaf of the plant can obtain nitrogen as well as carbon from the atmosphere is due to the difficulty that is thus introduced of explaining how the world's original stock of combined nitrogen can have arisen. Assuming the world to have cooled down from the state of incandescent gas, it must have started with all its nitrogen

* From the Journal of the Society of Arts.

in the free gaseous state, yet as we see it to-day all the stock of combined nitrogen is of organic origin.

The circulatory process through which combined nitrogen is put is very plain. Animals can only use the highly organized compounds like the proteids; these they break down during their vital processes to simpler compounds like urea and the amides, which in turn are taken by plants to be built up once more into the proteid complexes. This is, however, only a circulation, subject to occasional losses by breakings down as far as elementary nitrogen; there is never any bringing of fresh elementary nitrogen into the account.

TABLE VII.—BARLEY (Hellriegel and Wilfarth).

Nitrogen Supplied.	Dry Matter Produced.
0	0·51
0·028	3·0
0·056	5·6
0·112	10·8
0·336	29·3

TABLE VIII.—ROTHAMSTED MANGELS (1876-1902).

	Roots per Acre.	Increase per lb. of N.
	Tons.	Tons.
Superphosphate, and Sulphate of Potash	4·55	
Ditto. + 7·8 lb. N.	5·93	0·17
Ditto. + 86 "	14·03	0·11
Ditto. + 93·8 "	14·60	0·107

The stocks of combined nitrogen that have been handed down from past ages all speak of the same organic circulation, never of fixation. Coal is but the *débris* of an extinct vegetation; nitrate of soda, the glorified result of the same decay processes which give rise to nitrate of potash in India and nitrate of lime in the old niter beds. Virgin soils with their vast stores of nitrogenous humus are often looked upon as having gained nitrogen by the accumulation of long epochs of vegetable growth, but if plants cannot fix nitrogen there can have been no gain but only a circulation of the pre-existing combined stock. At first sight there seem no processes at work either to bring about the original combination or to repair the stock from time to time. Inorganic agencies are certainly trifling because nitrogen is a difficult element to bring into combination, so great an initial expenditure of energy is required to separate the atoms in the gaseous molecule. Electric sparks will bring about a combination of nitrogen and oxygen, and lightning flashes through the air have been invoked to account for the trace of nitric acid to be found in the atmosphere and in rain water. Such an origin, however, is still doubtful, for it has not been found possible to correlate variations in the nitric acid content of the rain with the frequency or otherwise of thunderstorms. Again, it has been supposed that during the evaporation of water there is always a slight combination of nitrogen with the elements of water to form ammonium nitrite, but more recent and refined experiments are against the existence of any such reaction.

There has, however, of late years been discovered one vital process capable of fixing nitrogen, which has probably been operative since the beginning of life on the earth, and this process is the property of certain groups of bacteria only. The history of nitrogen-fixing bacteria begins some thirty years ago with the resolution by Hellriegel and Wilfarth of the great outstanding difficulty in the theory that plants only make use of combined nitrogen. Though the demonstration in the laboratory of this opinion seemed perfect, and though in the main it was corroborated by field experiments, there was one group of plants—peas, beans, clover, and their allies—which seemed to derive little or no benefit from nitrogenous fertilizers and yet actually left the land richer in nitrogen after their growth, although in the crop removed there was an exceptional amount of nitrogen. That beans or vetches or lupins were the best preparation for a wheat crop was a commonplace of Roman agriculture, and the same observation became afterward enshrined in that most fundamental of rotations, the Norfolk four-course system, in which wheat follows clover or beans. Hellriegel and Wilfarth found that leguminous plants did gather nitrogen from the atmosphere, and could, therefore, become wholly independent of nitrogenous manures; but this only took place when, by infection from the soil, certain characteristic nodules were formed upon the roots. These nodules were found to be colonies of a particular bacterium which seem to live symbiotically on the host plant, furnishing it with nitrogenous matter and deriving from it the carbohydrate required for the fixation of nitrogen. As the fixation of nitrogen is a chemical process analogous to going up hill it requires a supply of energy from outside, which external source of energy the bacterium obtains by the oxidation of carbohydate in some form or other. The particular bacterium living in symbiosis with the leguminous plants seems to be highly specialized and has not been transferred to other non-leguminous plants; only with some difficulty it has been made to grow and to fix nitrogen when living alone and no longer in association with its host. With increasing knowledge of the methods of handling this organism, it seems probable that by cultivation we shall be able to obtain races showing variations in their power of fixing nitrogen, but how long they will retain this greater or lesser virulence after inoculation back to the leguminous plant is still uncertain.

The leguminous plants form then by their association with nitrogen-fixing bacteria, one considerable natural source of combined nitrogen, and how effective they can be in accumulating fertilizing matter in the soil may be judged from the accompanying table showing the results of some of the Rothamsted experiments upon leguminous crops.

The only practical limitation to the gathering of nitrogen by this method lies in the difficulty that is found in growing leguminous crops frequently on the same land. Although, as we have seen, it is possible to grow wheat year after year for more than half a century and maintain the yield if the appropriate manures are employed, on few soils can clover be grown with success more frequently than once in four

TABLE IX.

Manuring for Swede crop only.	Clover, 1894.	Wheat, 1895.			Roots, 1896.			Barley, 1897.		
		After fallow.	After clover.	Increase due to clover.	After fallow.	After clover.	Increase due to clover.	After fallow.	After clover.	Increase due to clover.
	cwt.	lb.	lb.	Per cent.	cwt.	cwt.	Per cent.	lb.	lb.	Per cent.
Mineral manure ..	59·7	4,220	5,180	+ 22·7	179·1	244·5	+ 36·5	2,103	3,991	+ 89·8
Complete manure	76·7	4,547	5,209	+ 14.6	379·8	388·8	+ 2·4	3,595	4,913	+ 36·7

and even once in seven years. As the farmer says, the land becomes "clover sick," and though the clover seed germinates and grows for a time the constitution of the plant is so weak, that it almost inevitably succumbs during the winter to an attack of fungoid or other disease. The determining cause of this weakness of constitution which lies at the back of "clover sickness" is still unknown, but preventing as it does the more extended use of these nitrogen collecting crops it would be of serious economic importance to find the cause and a remedy.

More recently, however, other bacteria have been discovered in the soil which are capable of fixing free atmospheric nitrogen without association with any host plant, provided they are supplied with some carbohydrate, from the oxidation of which they derive the energy necessary to bring the nitrogen into combination. Of these bacteria the best known and probably the most effective is a large organism, first examined by Beijerinck in Holland, and called by him *Azotobacter chroococcum*. It is widely distributed in cultivated soils both in Europe and America, and although I failed to detect it in the arid soils from the high veldt or the Karoo in South Africa, yet I obtained similar though perhaps slightly varying bacteria from cultivated soils in tropical East Africa and in Egypt. It appears to be active only when there is some calcium carbonate in the soil, possibly because in its oxidizing reaction certain acids are produced which must be neutralized before its activity will continue. Roughly speaking, its action is to oxidize carbohydrates to carbon dioxide and water, forming as by-products certain organic acids, e. g., butyric, and some dark brown humus (whence the name "chroococcum"), and incidentally bringing a certain amount of nitrogen into combination, not more, however, under the most favorable laboratory conditions than 1 to 2 per cent of the carbohydrate consumed. It is, however, extremely probable that we may look to this organism and its allies as the origin of the continued accumulation of nitrogen in such rich virgin soils as the black soils of the Russian steppes or of Manitoba. As long as these lands were uncultivated the annual fall of the leaf and dying down of the summer vegetation furnished the conditions necessary for the activity of the *azotobacter*. The carbohydrate-containing material thus returned to the soil provides the organism with its necessary food supply by the oxidation of which it gains energy to fix the atmospheric nitrogen. In cultivated soils where the crop is removed the action is almost brought to a standstill, as may be seen in the steady loss of nitrogen from the arable soils at Rothamsted during the fifty years they have been cropped without any extraneous nitrogen supply. Only when land is laid down to grass is there a sufficient amount of carbohydrate *débris* returned to the soil to allow of the gain of enough nitrogen to be evident in practice. A good example of the natural accumulation of combined nitrogen may be seen in two pieces of land at Rothamsted, which for the last twenty-five years have been allowed to run wild and assume a natural prairie condition of self-sown weeds and grasses that are never taken away but left to rot where they died down. Samples of the soil had been taken at the beginning of the period, and by comparing them with more recently taken samples it has been possible to detect a very considerable fixation of nitrogen, amounting in the most favorable case to nearly one hundred pounds of nitrogen per acre per annum.

The second similar piece of land shows a much lower result, and this is correlated with the absence of carbonate of lime in the soil of that plot and a corresponding absence of the *azotobacter* organism.

It is too early yet to speculate freely on the work of the various nitrogen-fixing bacteria; we may, however, confidently attribute to their action both the current stock of combined nitrogen in the world and the main source of its renewal in the future.

Attempts have already been made to raise these nitrogen-fixing bacteria artificially, particularly those associated with leguminous plants, and by introducing them into soil that was lacking or poorly supplied with them, to render it capable of self-enrichment in this most natural manner. Such cultures are, in fact, sold commercially at the present time and have in some cases been somewhat unscrupulously boomed as dispensing with the need for nitrogenous fertilizers. Undoubtedly cases may be quoted where the use of these pure cultures of nodule-forming bacteria has been of great service, generally on newly-reclaimed soils which have thus become for the first time capable of carrying a leguminous crop. But in old cultivated soils the organism is already present, and sufficient evidence is not yet forthcoming to show that the new introductions have had any effect; certainly the results obtained in the British Isles are almost wholly negative. Doubtless, the useful soil bacteria will be domesticated, improved, and made more effective just as our flocks and herds have been tamed and developed, while the useless ones will be stamped out as vermin; but at the present time we cannot be satisfied that any improved race of bacteria introduced artificially into the soil has managed to persist and get a real footing in face of the competition of the enormous natural bacterial flora already existing there. So the picture of the farmer carrying the manure for a field in his waistcoat pocket and applying it with a hypodermic syringe, is still a vision of the future.

These natural processes for the recuperation of our stock of combined nitrogen have, during the last year or two, been supplemented by one or two manufacturing processes of great interest in themselves, which are on the point of becoming factors of importance in the fertilizer market.

Speaking broadly, there are two ways of bringing free nitrogen gas into combination; first, at extremely high temperatures, such as are attained in the electric arc or sparks, nitrogen will combine with oxygen to form various oxides from which with water, nitric acid will eventually result; secondly, nitrogen will combine with a few metals and allied bodies, again at high temperatures, to yield substances which under the action of water yield ammonia. It is this latter method which was first developed on a commercial scale by Prof. Frank and Dr. Caro in Berlin. They did not exactly start with a metal but with calcium carbide, the substance now so well known as the source of acetylene for illumination. This body Frank and Caro found would combine readily with nitrogen gas at quite moderate temperatures, and the resulting substance, calcium cyanamide as it is called, or kalkstickstoff, will decompose under the action of water, yielding its nitrogen as ammonia and the calcium and carbon as calcium carbonate. In the manufacturing process the calcium carbide is first roughly ground and then heated in iron tubes through which a current of nitrogen gas is passed. The calcium carbide, which itself results from the reaction of a mixture of chalk and coke in the electric furnace, must either be purchased or manufactured by a preliminary process. The two reactions of forming the carbide and uniting it with nitrogen can indeed be carried out simultaneously, but this method has been abandoned in practice. The Italian company, which has now taken up the patents for the manufacture of calcium cyanamide, has established its factory alongside one of the great producers of calcium carbide at Piano d'Orte in the hills above Rome, where water-power can be obtained for the cheap generation of electricity. On theoretical grounds one electrical horse-power per annum should bring about the fixation of 772 kilogrammes of nitrogen, in practice 300 to 330 have been attained. The nitrogen gas is obtained by passing a current of air over red-hot copper, the copper oxide formed being afterward reduced to the metallic state again by sending over it a current of coal-gas while it is still hot. More recently a process of obtaining nitrogen by fractional distillation from liquefied air has been employed. The resulting calcium cyanamide is a dark gray, heavy powder, slowly reacting with the moisture in the air and giving off certain strongly smelling gases characteristic of calcium carbide itself. The normal product contains as much as 20 per cent of nitrogen, the theoretical substance being $CaCN_2$ with 35 per cent of nitrogen. With superheated steam it reacts to produce ammonia and calcium carbonates in accordance with the equation—

$$CaCN_2 + 3\,H_2O = 2\,NH_3 + 3\,CaCO_3.$$

With acids the reaction is rather violent and various highly nitrogenous bodies are produced. It is the first reaction, however, which is supposed to take place when calcium cyanamide is applied to the soil: it should change slowly into ammonia, which will be arrested by the soil, and calcium carbonate. It has been shown, however, by Löhnis, that the reaction with water alone is slow and not particularly effective, but that certain soil bacteria are operative and bring about the change in practice. Löhnis's conclusions have been confirmed in the Rothamsted laboratory, and it is certainly a remarkable fact that bacteria present in the soil should be capable of attacking so entirely novel a material. As a commercial fertilizer,

calcium cyanamide has been subjected to a series of fairly conclusive trials which would show that on most soils it is not quite so effective as sulphate of ammonia supplying an equal amount of nitrogen. For example Table X. shows the results of four trials at Rothamsted in 1905, mangels and barley being the crops under experiment. On soils poor in lime doubtless the cyanamide would give comparatively better results because then the carbonate of lime, which is the by-product of the decomposition taking place in the soil, would itself be of considerable value. The Rothamsted soil, however, contains sufficient carbonate

TABLE X.—ROTHAMSTED EXPERIMENTS WITH CALCIUM CYANAMIDE, 1905.

	Barley.		Mangels.		
	Grain.	Straw.			
	Bushels	Cwt.	Tons.	Tons.	Tons.
Calcium cyanamide	34·3	19	22·0	11·1	28·9
Sulphate of ammonia	37·5	24	23·5	10·0	27·9

of lime to minimize the effect of this factor. The chief drawback to the practical employment of calcium cyanamide as a manure is its chemical activity and sensitiveness to the action of water. It must travel in air-tight drums, as it not only deteriorates in damp air but generates gases, some of which are dangerous and inflammable. It cannot be mixed with other manures; a mixture with superphosphate, in particular, gets unpleasantly hot, even on a small scale. It has, therefore, to be sown on the land alone, and it should be incorporated with the soil a week or two before any seed is sown. If left on the surface there will be loss of ammonia, and even in the soil the ammonia and other gases evolved at first are injurious to the germination of seed. For similar reasons it cannot be used as a top dressing. These difficulties in handling the material are likely to prove serious drawbacks to its use by the ordinary farmer, and it is a question whether it would not be wise for the manufacturers to push the process a stage further and actually turn out an ammonia compound. For example, it is probable that calcium cyanamide could easily be made to react with superphosphate to produce a double phosphate of calcium and ammonium, which would be a valuable manure of a type that farmers are familiar with, miscible also with nearly all other fertilizers.

The other method of bringing nitrogen into combination—that of effecting its union with oxygen at the temperature of the electric arc—has received considerable attention, and forms the base of at least two working processes. It will be remembered that when Sir William Crookes in 1898, in his British Association address, warned the world of the rapidly progressive exhaustion of its supplies of combined nitrogen, it was to the union of nitrogen with oxygen that he looked for the future supply of combined nitrogen for the wheat crop, and he showed experimentally how the two gases would burn together at a very high temperature. Not enough heat, however, is given out by the flame to bring more gas up to the ignition point, hence the flame is only continuous as long as external energy is poured in. The reaction which takes place is expressed by the equation—

$$N + O = NO - 21.6\ K.$$

Energy to the extent of 21.6 kalories is required to bring 14 grammes of nitrogen into combination.

Calculating from the best results Lord Rayleigh had obtained in bringing nitrogen and oxygen into combination by the electric spark, Crookes decided that if electricity could be obtained at 1-17th of a penny per Board of Trade unit, as it was expected would be the case at Niagara, then nitrate of soda could be made artificially at about $25 per ton.

Such an electrical process was installed at Niagara by Bradley and Lovejoy, who produced a number of arcs between platinum poles with a continuous current at a potential of 10,000 volts. The oxides of nitrogen generated were converted into nitric and nitrous acids by steam and more oxygen, and a mixture of sodium nitrite and nitrate was prepared for agricultural purposes. The installation, however, ran for fifteen months only, for though considerable amounts of nitric acid were produced, technical difficulties in maintaining the apparatus in working order proved insuperable. More recently what promises to be a really working process has been devised by Prof. Berkeland, and is running on a commercial scale at Notodden in Norway. In the Berkeland-Eyde process an alternating current at about 5,000 volts is set to form an arc between U-shaped copper electrodes, which are hollow and kept cool by a current of water within. The electrodes are placed equatorially between the poles of a powerful electro-magnet which has the effect of causing the arc to spread out into a broad flat flame. Though the temperature of the arc-flame is calculated to be 2,600 deg. C. it is not particularly luminous; it may be looked at directly from a yard's distance.

Through the furnace in which this special arc is generated about 15,000 liters of air are blown per minute at gentle pressure, and the issuing air contains about 1 per cent of nitric oxide and is at a temperature of 600 deg. to 700 deg. C. It is cooled and then passes into two oxidizing chambers where the combination of the nitric oxide with the oxygen of the uncombined air takes place, after which it passes into a series of five condensing towers. Down the fourth tower, which is filled with broken quartz, water trickles, and picks up enough of the nitrous gases to become 5 per cent nitric acid at the bottom; this is pumped up and trickles down the third tower, the process being repeated until the liquid leaving the bottom of the first tower contains 50 per cent of nitric acid. In the fifth and last tower the absorbing liquid is milk of lime, and the resulting mixture of solution of calcium nitrite and nitrate is treated with enough of the previously-formed nitric acid to convert it wholly into nitrate, the nitrous fumes evolved being led back into the oxidizing chamber. The product is then concentrated until it solidifies as a material containing about 13 per cent of nitrogen, or 75 per cent of pure calcium nitrate. Owing to the hygroscopic nature of calcium nitrate, it is found better to introduce an excess of lime and manufacture a basic nitrate for agricultural purposes.

The present factory has three electric furnaces installed, each employing 500 kilowatts, and the production amounts to about 150 kilogrammes of nitrogen fixed per kilowatt year, or about one-fortieth of the maximum possible from the energy equation with which we started.

Prof. Berkeland calculates that the cost of manufacturing calcium nitrate containing 13 per cent of nitrogen is about $20 per ton, and that it can be sold at a profit at $40 a ton, which would be equivalent to nitrate of soda at about $50 a ton. The present factory at Notodden has been putting calcium nitrate on the market for about a year and a half, the rate of production now being about 100 tons per month. A new factory is being built which will generate about 30,000 horse-power, and contain larger furnaces, taking each 750 kilowatts, and when this is in operation it is expected the output will amount to 1,000 tons per month. As a fertilizer there cannot be the least doubt that nitrate of lime will be just as valuable, nitrogen for nitrogen, as nitrate of soda. At Rothamsted a chemically prepared nitrate of lime has been used for two or three years for a special purpose on one of the mangel plots, and it has given exactly equal results to the nitrate of soda plot alongside. Many field experiments have also been carried out with the electrical product in Norway during the last year or two, and have shown that the new material can be strictly valued against nitrate of soda on the basis of the nitrogen it contains. Indeed, on some soils it is likely to be more valuable, because, as will be shown in the next lecture, part at least of the lime base will be left behind in the soil as calcium carbonate. This will be an advantage in peaty soils, and will also save clay soils from the peculiar wetness and stickiness which results from the employment of much nitrate of soda.

It will be observed that the commercial production of these two new manures which science promises to put very shortly at the service of the farmer, calcium cyanamide and calcium nitrate, is entirely dependent upon a cheap source of electric power; a cheapness which cannot be obtained when the electricity has to be generated by coal, but which is only attainable with water power costing practically nothing beyond the interest on the capital sunk in the installation of turbines and dynamos. In this respect our country is always likely to be at a disadvantage, so that we must look to receive our supplies of these new nitrogenous fertilizers from countries which combine considerable elevations with an abundant rainfall. Indeed, in the British Islands the proprietor of a waterfall of any magnitude is in a somewhat delicate position, for should he wish to turn it into power for one of these purposes he is sure to find a strong body of public opinion arrayed against him, an opinion too which is generally capable of bringing a good deal of indirect pressure to bear.

Meantime, while these processes are being perfected and the price of the unit of nitrogen in fertilizers is being reduced until the nitrate of soda exporters have to struggle to sell their article at a profit at all, it is to be hoped that progress will also be made with the biological fixation of nitrogen. If clover sickness could be got rid of so as to enable the farmer to introduce what is after all much the most generally profitable leguminous crop more frequently into his rotation, if the nitrogen fixing bacteria in the soil could be given a freer play, and particularly if the nitrogen-wasting bacteria in the soil can be reduced, we shall go far toward rendering the farmer independent of any external nitrogenous fertilizer. It is not always realized how very wasteful of nitrogen our soil is; for example, of the nitrogen applied to the Rothamsted wheat plot as farmyard manure during the last fifty years only 21.6 per cent has been recovered in the crop; where it has been applied to the mangel crop about 10 per cent more has been recovered. The rest has either been permanently lost as free nitrogen gas or remains in the soil as compounds which will only be transformed into plant food with the utmost slowness. The nitrogenous compounds in the farmyard manure must be broken down and oxidized by bacteria before they are available by the plant. These figures show how imperfect the process is, because many of the soil bacteria are either wasters of or competitors for the nitrogen supplied as manure. Some recent experiments have shown that by partially sterilizing a soil its powers of crop production are doubled or trebled, probably because the plant is relieved from the competition of soil bacteria wanting nitrogenous food for their own development. It is not too much to hope that in time these laboratory experiments will get translated into practice and the soil made a much more effective medium than it is at present.

However that may be, cheapened nitrogenous fertilizers will be of special service to British agriculture; we cannot compete when a crop has to be grown cheaply over a wide area of land, a paying wheat crop in this country must yield something like 40 bushels to the acre, and if the manure required to bring up our production to that average costs too much, it may not be possible to grow the crop at a profit either on a higher or a lower level of production.

(To be continued.)

THE SHAPE OF MOLECULES.

By W. F. BADGLEY.

IT is now generally admitted that the shape of the molecules of the elements bears some close relation to the crystalline forms of their combinations, and Dr. Tutton has found that the angles of the crystals of each substance are identical, while they differ from those of all others, and it is no doubt owing to this difference of their molecular forms that some metals refuse to form alloys together, and other elements refuse to combine.

Also Messrs. Hadfield and Fleming have shown by their researches that there is some movement possible to the molecules of even the hardest of the metals at their coldest; as, for instance, in the iron, with 20 per cent nickel alloy, that is non-magnetic when made, becomes magnetic on cooling with liquid air, retains the property on return to ordinary temperature, and is found to be permanently expanded.

Further, it is allowed that the molecules at the surface of all substances are constantly being detached, some quickly, as water, others very slowly, as gold, but what governs the dispersion requires explanation, as substances act very differently under different circumstances. The molecules from the surface of a piece of gold pressed against a piece of lead disperse into the lead; this takes years, but they pass much faster than they do into air or water. The surface molecules of water disperse quickly into air, but refuse to enter oil. The molecules of common salt readily disperse in water, but refuse to enter air or most solids in any appreciable quantity.

Probably what happens in all cases of dispersion or solution is this—the surface molecules, being unconnected on one side and partially free from cohesion, are partly expanded from the crystalline shape, and the pressure of the surrounding molecules of air, fluid, or other substance has sufficient force to shoulder off these semi-detached molecules, and complete the separation. When separated, they are no longer crystalline. If elements, they are spheres, and if compounds, they assume some such shape as bubbles do when joined together, always arranging so as to be as nearly spherical as possible; never are they arranged in pancake form, like corks floating in a basin; the free behavior of all fluids sufficiently proves this.

In speaking of osmosis, the word "pressure" is used as if the water was forced through the membrane into the solution. It is the other way about; it is the change of form and dispersion of the molecules of the solute that draws the water through the diaphragm. When the salt changes from the crystalline to the spherical shape, interspaces are formed between the molecules, and the water is drawn in to fill these; also the salt molecule is not settled comfortably, until it has found, for itself alone, an interspace among the water molecules; when all the salt molecules are surrounded with water molecules, the pressure, as it is called, ceases.

All the properties of matter point to this, that in the solid their molecules are of such form as to allow of close contact and cohesion, and in the liquid and gaseous states, that they are as nearly globular as their composition will allow, and that their dispersion depends, not on any antagonism among them (for that would imply a molecular force that there is nothing to originate), but merely on the pressure of the atmosphere, which obliges every molecule to seek some interspace, where it will be most free from pressure.

In solution and in vapor, the compound molecule floats with its heavier component downward, and with a liquid or gaseous barrier round it. Anything that will break up this arrangement, as a glass rod or an electric current, will hasten chemical change between different substances in solution. A current of electricity sent through a solution (as shown by Mr. Whetham in some beautiful experiments) produces movement and change, driving the metallic component in one direction. The current passes with a rapidity comparable to that of light; the carrier takes hours to move an inch. The electricity passes in small charges, that go from molecule to molecule, giving the metallic component, on which alone it can act, a backward kick that sends it toward the next already vacant acid molecule of the string. In this way the metal is propelled one way, and the acid drawn in the opposite direction, and slow decomposition results at each node.

From the behavior of electricity on all occasions, one would judge that it is not a substance of any sort, but a vibration—a vibration that finds itself in harmony with metal almost exclusively. As heat and light are to ether, and sound to grosser air, so is electricity to gross metal.

But this paper was written to express ideas regarding the shape of molecules, and electricity, if the above is true, must be devoid of form.—Knowledge & Scientific News.

HOW TO BUILD A 5-HORSE-POWER STATIONARY GAS ENGINE.*

By E. F. LAKE.

IN starting to construct a gas engine, the first and most important part is the designing. The horsepower desired is generally taken as a starting point, and from it are figured the bore of the cylinder, the length of stroke, the size and lift of the valves, the compression, the clearance of the piston, the speed of the gases at the inlet and exhaust valves, the length and diameter of the bearings, the size and shape of the cams, the tension of the valve springs, the thickness of the metal in the cylinder, the size of the water jacket, the size and strength of the connecting rod and crank shaft, the diameter and weight of the flywheels, and numerous other things which must be exact in their dimensions to insure a smooth running engine, which is strong enough to wear well and which at the same time does not have too much metal in its different parts to add to its cost, weight, and bulkiness.

With the designing properly done and the dimensions decided on, the drawings can be made for each part, so that the whole can be assembled without any interference of the different parts, and with the assurance that each part will fit in its place.

In designing this engine I have adopted the four-cycle principle with mechanically-operated valves, because this style gives the best satisfaction, for the reason that it scavenges the combustion chamber better than the two-cycle. Also because it admits the gases with the assurance of a full charge, better than the automatic inlet valve, and is therefore more economical in the use of fuel.

The design has been made as simple as possible, so that the amateur mechanic with a lathe, a drill press, and the necessary hand tools, can build the engine from the drawings.

Cylinder Pattern.—With the drawings completed, the first operation, in the building of this engine, is the making of the patterns. The cylinder being the most important part, it will be taken up first. In making this pattern, the first thing to be decided on is where the best metal is required in casting. The pattern should be made so that the best metal will be in the bottom of the mold; for gas bubbles, loose facings, sand, etc., being lighter than molten iron, float to the top of the mold and are liable to lodge in pockets, causing imperfect or porous castings. In our engine cylinder, as illustrated by **Figs. 1, 1A, and 1B**, the best metal that it is possible to obtain is needed around the compression chamber and valve seats. The lower part, where the cylinder is bolted to the base, is covered by the piston when at the lowest point of its down stroke, and is therefore not as important. Gas bubbles are not so likely to form and there is less chance of porosity. All that is required of the metal is strength enough to hold it firmly to the base when the cylinder is bolted down. Therefore, to mold the top of the pattern in the bottom of the mold a three-part flask ought to be used. The pattern is parted on the line *BB*, Fig.

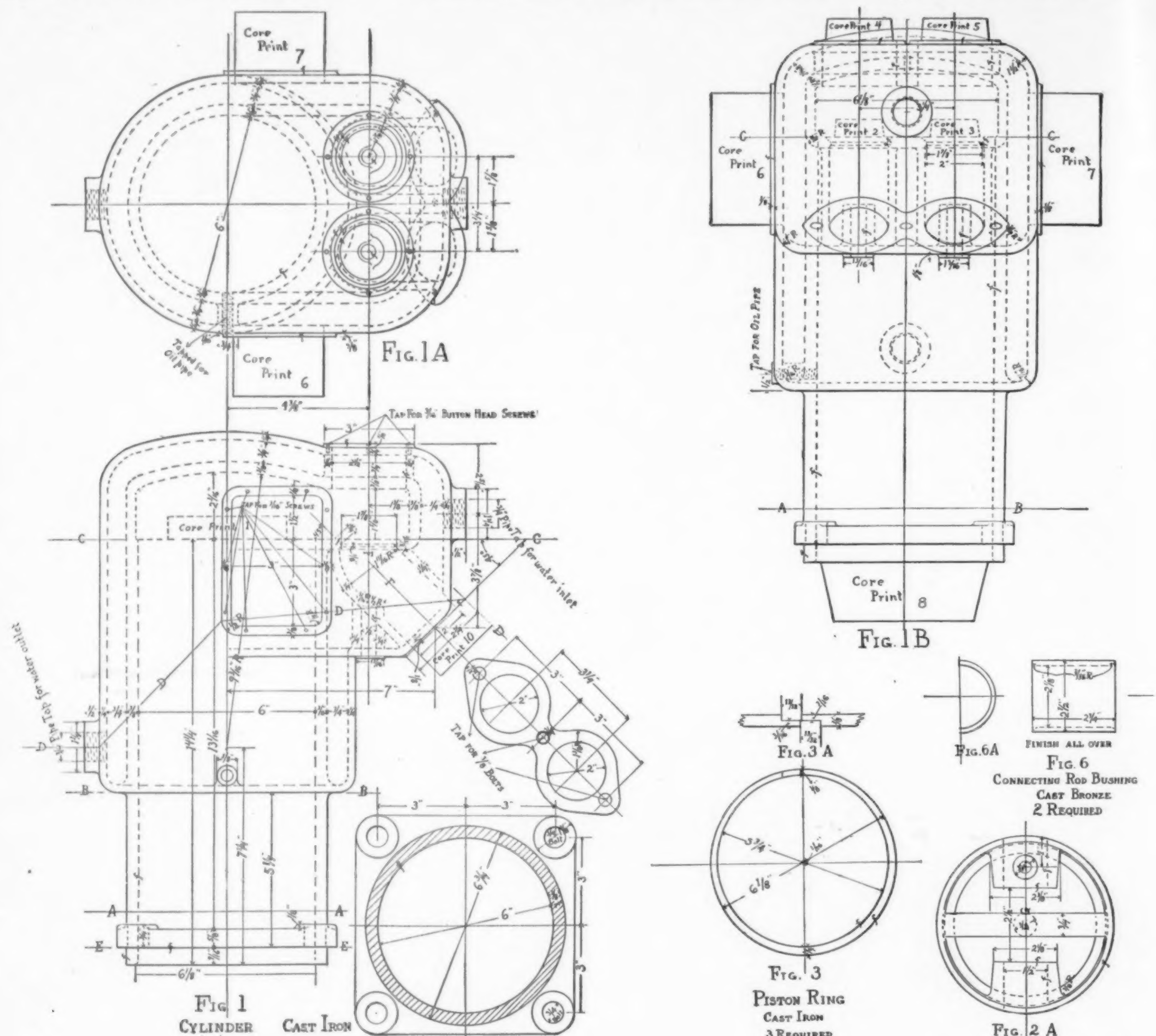


FIG. 1A

FIG. 1B

FIG. 1 CYLINDER CAST IRON

Section AA

FIG. 3A

FIG. 3 PISTON RING CAST IRON 3 REQUIRED

FIG. 6A

FIG. 6 CONNECTING ROD BUSHING CAST BRONZE 2 REQUIRED

FIG. 2A

FIG. 4A

FIG. 5A

FIG. 5 CONNECTING ROD CAP CAST STEEL

FIG. 5B

FIG. 4 CONNECTING ROD STEEL FORGING

FIG. 2 PISTON CAST IRON

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

1, and the mold on the irregular line *DDDD*. If many castings are to be made a match board should be built to this irregular line so as to make the parting easy for the molder. The second parting of the mold may occur on the line *EE*. The pattern may then be lifted out of the sand by raising the cope, bearing the imprint of the core print 8, Fig. 1B. That part of the pattern should then be drawn out to the line *BB*, after which the cheek or middle part of the flask may be lifted and the remainder of the pattern extracted. The boss for the inlet water pipe is necessarily loose on the pattern and must be picked out of the mold after the rest of the pattern has been drawn.

The cores should be parted on the line *CC*, Fig. 1, with the exception of the water jacket core which lies above the line *CC*, and is parted from *C* on the left along that line to *F* (the center line of the inlet and exhaust passages). From this point the parting line follows the line *FF*. This portion of the water jacket is then set by locating in core prints 6 and 7, Figs. 1A and 1B. After this the compression chamber core should be made to the exact line. A variation of 1/32 of an inch either way may result in the washing out of the cores from their positions and produce a casting with thin metal on one side and thick on the other.

One-eighth of an inch should be allowed for machining on the pattern in all places where it is marked *f*, except in the cylinder bore. Here the finish allowed should be 5/32 of an inch, because a very smooth surface is desired for the piston. The cylinder bore should have a roughing cut turned off and after this a very light finishing cut.

The metal which gives the best satisfaction for wear and fit for the cylinder, piston, and piston rings is a close-grained cast iron. If properly turned and ground this metal presents a glass-like surface which does not wear away readily and is not subject so markedly to expansion as other metals. Steel has often been employed for these parts, but it does not wear nearly as long as cast iron. The best cast irons for this purpose are obtained in the air or reverberatory furnace, because better analyses are possible than with the cupola.

piston in the bottom of the mold. Thus a close-grained iron is produced, free from imperfections and most compact where it must withstand the explosive pressure. The core can be made in one piece by parting the core box on the center line *G*. The bar across the open end of the piston, for centering it in the lathe, can be parted on this same center line and drawn out through holes in each side of the core box after the core is rammed up. By mounting the piston pin bosses loosely, the box can be drawn away from the core, after which the bosses can be drawn out.

The pattern and core print can then be all molded in the drag, the pattern drawn out, the core lowered in position and located by the core print 9, and a flat cope put on which will hold the core securely in position. If the core box and core print are made the correct size there will be no danger of the core's washing to one side. The finish allowed on the side of the piston should be 5/32 of an inch, as it must be turned and ground with the same exactitude as the bore of the cylinder.

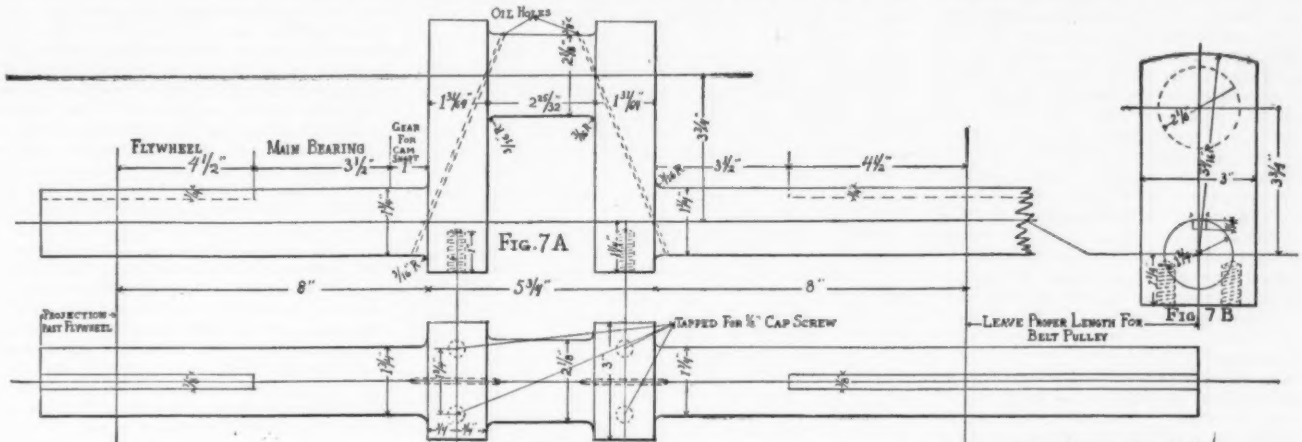


FIG. 7
CRANK SHAFT STEEL FORGING

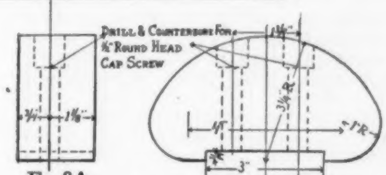


FIG. 8A

FIG. 8
COUNTER BALANCE FOR CRANK SHAFT
STEEL CASTING

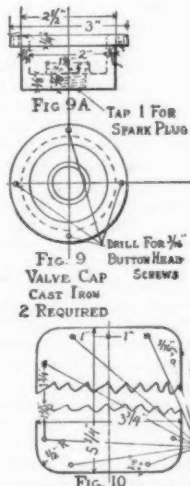


FIG. 9A

FIG. 9
VALVE CAP
CAST IRON
2 REQUIRED

FIG. 10

FIG. 10A
WATER JACKET PLATE
2 REQUIRED
SHEET STEEL OR BRASS

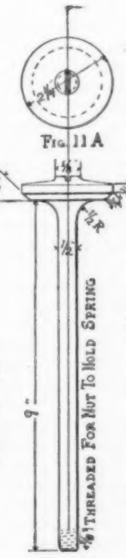


FIG. 11A

FIG. 11
VALVE
2 REQUIRED

FIG. 12
VALVE SPRING HOLDING NUT
2 REQUIRED
STEEL

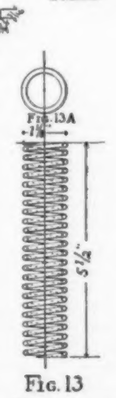


FIG. 13A

FIG. 13
VALVE SPRING
2 REQUIRED
*20 STEEL WIRE

FIG. 14A

FIG. 14
VALVE ROD
2 REQUIRED
STEEL

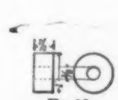


FIG. 15
CAM ROLLER
2 REQUIRED
STEEL

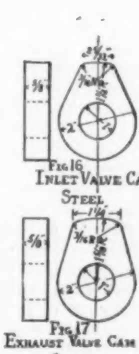


FIG. 16
INLET VALVE CAM
STEEL

FIG. 17
EXHAUST VALVE CAM
STEEL

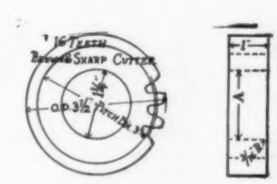


FIG. 18

CAM SHAFT GEAR ON CRANK SHAFT
STEEL OR BRONZE

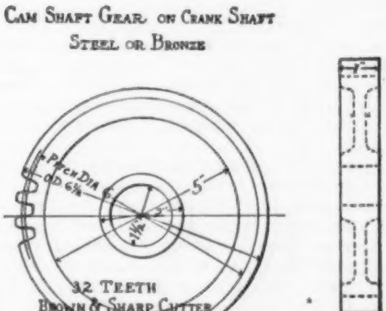


FIG. 19. CAM SHAFT GEAR ON AUX. SHAFT STEEL OR BRONZE

FIG. 19A

above the line *CC* is set by passing it through the water jacket core and locating it in core prints 4 and 5, Fig. 1B. The opposite end of this core should be supported by a chaplet. The inlet and exhaust passage cores are next set in the core prints 2 and 3, which have left their impression in the compression chamber core. On the other end these cores are supported by the core print 10, Fig. 1. The portion of the water jacket core below the line *CFF* is deposited in the core prints 6 and 7 and pasted to that part of the water jacket core which is in the mold. The cylinder core may then be lowered into the core print 1, Fig. 1, which has left its impression in the compression chamber core. The mold is then closed by affixing the cheek, which closes over the inlet and exhaust passage cores at core print 10, thus holding them firmly in position. Next the cope is placed on, and this closes over the cylinder core at core print 8, Fig. 1B, thereby locking all the cores together and preventing them from floating out of place when the metal is poured into the mold.

For the reason that the cores fit into one another, the pattern with its core prints and the core boxes

One of the best cast irons for cylinders shows the following composition on analysis:

Graphite carbon	2.80%
Combined carbon	.58%
Silicon	1.78%
Sulphur	1.75%
Phosphorus	——
Manganese	.44%

Piston and Ring Patterns.—The piston, as shown in Figs. 2 and 2A, is made, by the majority of pattern makers, by parting on the center line *G*, coring out the center and molding one-half in the drag and the other half in the cope of the mold. This, however, is not the best way, as it would be difficult to keep the core in the center and the best iron would be on one side, while the lighter iron and bubbles would gather on the cope side of the castings. The best results are obtained by making the pattern solid, by applying overhanging prints as shown by the core print 9, and by adjusting the top of the piston to the bottom of the mold, inasmuch as the weight of the remaining iron in the mold presses on the metal in the head of the

The piston rings are usually cast in a tube long enough to make a number of rings. For our engine a tube 6⅜ inches in diameter on the outside, 5⅝ inches diameter on the inside and 2¼ inches long will give plenty of stock to turn the three rings, cut them off and leave enough to chuck in the lathe. If a number of engines are to be built the tube can be made from 12 to 18 inches long by using a metal pattern with very little draft. A wooden pattern, however, needs so much draft that 8 or 9 inches would be the maximum length for the tube. Greater lengths can hardly be worked economically.

The Base Pattern.—The base is the largest piece for which a pattern is needed, but is not as important as the cylinder or piston, so far as the quality of the iron is concerned. Blow holes can be plugged up and the whole painted over, so that defects will not be visible. The metal must be strong enough, however, to support the crankshaft with its flywheels, connecting-rod and piston and to withstand the thrust of the explosions.

This base as shown in Figs. 20, 20A and 20B* is most

* See next number.

easily molded by parting on the center line *HH*, Fig. 20A, and locating the side with core print 13, in the bottom of the mold.

Hence the pattern is made in two halves and assembled with dowel pins. The bosses for the valve rods are mounted loosely, likewise the projections to house the cam shaft gear. After the pattern is drawn from the mold these parts may be withdrawn. The holes for the cam shaft, auxiliary shaft, and valve rods are preferably left to be drilled because of the difficulty of locating cores for them. This would leave the main core to be made in two halves by parting the core on the center line *HH*, Fig. 20A. After the pattern is drawn from the mold, the lower half of the core can be lowered into the core print 13 and located by the core prints 10, 11 and 12, Fig. 20. After this the top half of the core can be applied, pasted to the lower half and located by the same core prints. The mold is then ready to be closed to receive the metal.

Flywheel Pattern.—The pattern for the flywheels, Figs. 21 and 21A, of which two are required, are simply made, because no cores are required. The flywheel can be solidly built so that the molder can make the parting. If a number of engines are to be built, a match board built up to the center of the spokes, on the inside of the wheel, may be used to make the parting, thus saving much work in the foundry. These patterns, all of cast iron, should be made 1/10 of an inch to the foot larger than the finished casting, to allow for the shrinkage of the metal in cooling.

The Smaller Patterns and Castings.—The valve caps, Figs. 9 and 9A, are also of cast iron. The pattern is easily made. The caps fit in the opening over the valves in the cylinder at core prints 4 and 5. These openings are left so that the valves can be inserted and the caps taken out at any time to clean or re-seat.

The cap for the main bearings, Fig. 26, of which two are required are also made of cast iron. The patterns can be made plain without any cores. These fit the bearings in the base.

The glands for the inlet and exhaust connections, Fig. 27, are best made of cast brass, but they can be made of cast iron if desired. If iron be the metal selected, they should be made 2½ inches in diameter where the drawings indicate 2¼ inches and 2⅝ inches where 2⅜ is marked. Owing to the openings being drilled out, the pattern can be made to leave its own core.

The bearing bushings, Figs. 6, 6A and 27, 27A, should be cast of a special bearing bronze that can be produced by any brass foundry; this makes the most durable bearing of any metal for gas engines, as it will withstand the thrust from the explosions much better than babbitt or other bearing metals.

The water jacket plates, Fig. 10, the plate for the hand hole in the base, Fig. 23, and the plate to cover the hole made to allow the crank shaft to be placed in position, Fig. 24, can be made in cast iron, and if this is done the pattern should be bulged in the center, as it will give a more pleasing effect to the eye than a flat plate as shown in the drawing. If made of cast iron these plates should be about ¼ of an inch thick on the edges; but if sheet steel or sheet or cast brass is easier to obtain, they can be ⅛ of an inch thick or even 1/16 in the case of sheet metal. The water jacket plates, however, must be secured with gaskets to make them water tight.

The counter balance for the crank shaft, Fig. 8, can also be made of cast iron, although cast steel would be better because there would be no danger of its breaking and damaging the engine.

The four gears necessary to transmit the power from the crank shaft to the cam shaft, Figs. 18, 19 and 22, can be made of blanks cast of manganese bronze, which will wear as well and machines easier than steel. A good grade of steel is as good as any material if this is easier to obtain.

The patterns for brass or bronze castings should allow 2/10 of an inch to the foot for shrinkage.

Finishing the Cylinder.—Of the different stages in the work of building a gas engine, none is more important than the machining and finishing of the cylinder. Upon the proper boring and grinding of the cylinder and the fitting of the piston with its rings largely depend the power, economy and smooth running of the engine.

The cylinder can be bored by fastening it to the carriage of a lathe and using a boring bar in the head. The boring bar may be provided with two cutters working on opposite sides of the bore of the cylinder, one to take off the roughing cut of about 3/16 of an inch and the other to take off the finishing cut of about 1/16 of an inch, leaving the cylinder bore a few thousandths of an inch less than 6 inches in diameter, for grinding to the exact size. Care must be exercised to have the sides of the bore straight, parallel, round and as smooth as it is possible to finish them. It is good practice to anneal the cylinders before boring them in order to break down any internal molecular strains which may have arisen in casting and cooling in the mold. If convenient it is also advisable to have a current of hot water running through the cylinder while grinding to keep it at the temperature it will be under when the engine is running.

Several methods are used in grinding. A small emery wheel revolving at a high rate of speed and traveling around the bore of the cylinder is most commonly used. This requires considerable rigging or special tools. Results equally as good can be obtained by the use of a lap, turned by hand with the aid of a wrench, or revolved in the lathe. With this lap fine powdered glass and oil is the best abradant to use in grinding. Emery has a magnetic attraction for iron and lodges in the pores, thus often cutting the piston and rings when the engine is running.

The cylinders should be ground and polished to a plate glass smoothness to insure good wearing qualities.

Another method of fitting the piston with its rings to the cylinder is to assemble them, after boring and turning, with the base, crank shaft and connecting-rod. By slipping a pulley on the crank shaft and belting it to the main shaft or a counter shaft in the shop, the cylinder and piston are worn into position and a fit.

This is a method which gives a good, hard finish to the bore of the cylinder and the piston rings. It has the disadvantage of requiring much more time than lapping or grinding. Several days must elapse and much oil employed before a good hard surface is obtained.

Before taking the casting from the lathe the bottom of the cylinder, on the line *EE*, Fig. 1, as well as the projection, which fits into the base, should be turned up, so that they will square with the bore. This done the bolt holes for bolting the cylinder to the base should be drilled. With the aid of these it can be secured to the bed of the drill press, the holes for the valve caps drilled, the tops of these counterbored, the valve seats drilled and beveled to an angle of 45 degrees and the holes for the valve stems drilled.

The bosses around the valve stems, on the under side of the cylinder should be correct in size, so that the valve springs may fit over their outer diameter, so as to hold the springs in their proper place and away from the valve stem.

Next the bearing for the gland, for the inlet, and exhaust connections, must be faced off at an angle of 45 degrees to the bore of the cylinder. Then the bearings for the water jacket plates at the openings in either side, left to support the core and clean it out after the cylinder is cast, are machined. These bearings need no very careful machine work as long as they are finished off flat, so that when the plates and glands are bolted on with the gaskets, there will be no leakage of water or gas. After this the holes for the water inlet and outlet and the hole for the oil pipe are drilled and tapped. The cylinder is then complete.

(To be concluded.)

SOME ASTRONOMICAL PARADOXES.*

By J. E. Gore, M.R.I.A., F.R.A.S.

The term "paradox" is sometimes applied to the idea of a flat earth, the non-rotation of the moon on its axis, and other false hypotheses "contrary to received opinion." But the word is also defined as "a statement or proposition which seems to be absurd, or at variance with common sense, or to contradict some previously ascertained truth, though when properly investigated it may be found to be perfectly well founded" (Imperial Dictionary). It is in the latter sense that I propose to deal with some astronomical facts which, although at first sight apparently incorrect or even incredible, are nevertheless quite true.

It is probably a matter of common observation—at least, among those who have paid any attention at all to the heavens—that the stars are not all of equal brightness. St. Paul says: "One star differeth from another star in glory."† There are stars of all degrees of brilliancy, from Sirius down to a star just visible to the naked eye on a clear, moonless night. And below this brightness there are thousands and millions of fainter stars, some visible in an opera glass, others in small telescopes; while the faintest are only visible in the largest telescopes yet constructed. Now, it was a natural supposition, and one held for many years, that the brightest stars are invariably the nearest to the earth and that the fainter stars lie at greater distances. But measures of parallax show that this conclusion is by no means correct. It is true that the nearest star to the earth, α Centauri, is one of the brightest stars in the sky—third in order of brightness—but there are several comparatively faint stars which are nearer to us than some of the brightest stars. Thus the small star known as Lalande 21,185 of magnitude 7½, and, therefore, invisible to the naked eye, is a little nearer to us than Sirius, and the bright star Capella is about five times farther from the earth than 61 Cygni, a star of only the 5th magnitude. The explanation of this apparent paradox is, of course, that the stars are not all of the same size and intrinsic brightness of surface; some are large bodies at a great distance from the earth, while others are comparatively small bodies, but much nearer to us.

The bright star Capella forms a curious anomaly or paradox. Spectroscopic observations show that it is a very close binary pair. It has been seen "elongated" at the Greenwich Observatory with the great 28-inch refractor—the work of Sir Howard Grubb—and the spectroscopic and visual measurements indicate that its mass is about 18 times the sun's mass. But its parallax (about 0".08) shows that it is about 128 times brighter than the sun! This great brilliancy is inconsistent with the computed mass of the star, which would indicate a much smaller brightness. The sun placed at the distance of Capella would shine as a star of about 5½ magnitude. As the spectrum of Capella closely resembles the solar spectrum, the discrepancy between the computed and actual brightness cannot be explained satisfactorily, and the star remains an astronomical enigma.

Another curious paradox connected with binary stars has recently come to light. For many years it was almost taken for granted that the brighter star of the pair has a larger mass than the fainter component. This was a natural conclusion, as both stars are practically at the same distance from the earth. But it has been found recently that in some binary stars the fainter component has actually the larger mass! Thus, in the binary star ϵ Hydræ the "magnitude" of the components are three and six, indicating that the brighter star is about 16 times brighter than the fainter component. Yet calculations by Lewis show that the fainter star has six times the mass of the brighter! In 70 Ophiuchi Prey finds that the fainter star has about four times the mass of the brighter star. In 85 Pegasi the brighter star is about 40 times brighter than its companion, while Furner finds that the mass of the fainter star is about four times that of the brighter! And there are other similar cases. In fact, in these remarkable binary combinations of suns the fainter star is really the "primary," and is, so far as mass is concerned, "the predominant partner." This is a curious anomaly, and cannot be well explained in the present state of our knowledge of sidereal systems. In the case of α Centauri the masses of the components are about equal, while the primary is about three times brighter than the companion. But here the discrepancy is satisfactorily explained by the difference in the character of their spectra, the brighter component having a spectrum of the solar type, while the fainter seems further advanced on the road of evolution. In the case of Sirius and its faint companion, the mass of the bright star is about twice the mass of the satellite, while its light is about 40,000 times greater! Here the satellite is either a cooled-down sun, or, possibly, a gaseous nebula. There seems to be no other explanation of this remarkable paradox. The same remarks apply to Procyon, where the bright star is about 100,000 times brighter than its faint companion, although its mass is only five times greater.

An apparent paradox is found in the case of the gaseous nebulæ. The undefined outlines of these objects render any attempt at measuring their distance very difficult, if not impossible. Their distance from the earth is, therefore, unknown, and likely to remain so for many years to come. It is possible that they may not be farther from us than some of the stars visible in their vicinity. On the other hand, they may lie far beyond them in space. But whatever may be their distance from the earth it may be easily shown that their attraction on the sun is directly proportional to their distance; that is, the greater their distance the greater the attraction. This is evidently a paradox, and rather a startling one, too. But it is, nevertheless, mathematically true. *Their distance being unknown*, they may be of any dimensions. They might be comparatively small bodies relatively near the earth, or they might be vast masses of gas at an immense distance from us. The latter is, of course, the more probable. In either case the *apparent* size would be the same. Take the case of any round gaseous nebula. Assuming it to be of globular form, its *real* diameter will depend upon its distance from the earth. As the volumes of spheres vary as the cubes of their diameters, it follows that the volume of the nebula will vary as the cube of its distance from the earth. As the mass of an attracting body depends on its volume and density, its real mass will depend on the cube of its distance, the density, although unknown, being a fixed quantity. If at a certain distance its mass is M, it would, at double the distance (the *apparent* diameter being the same), have a mass of eight times M (eight being the cube of two), and at treble the distance its mass would be 27 M, and so on, its *apparent* size being known, but not its *real* size. This is obvious. Now the attractive power of a body varies directly as its mass; the greater the mass the greater the attraction. Again, the attraction varies *inversely* as the square of the distance, according to the well-known law of Newton. Hence, if d be the unknown distance of the nebula, we have its attractive power varying as d^3 divided by d^2, or directly as the distance d. We have thus the curious paradox that for a gaseous nebula whose distance is unknown its attractive power on the sun will vary directly as its distance, the greater the distance the greater the attraction, and, of course, conversely, the smaller the distance the less the attractive power. This result seems at first sight absurd and almost incredible, but a little consideration will show that it is quite correct. Consider a small wisp of cloud in our atmosphere. Its mass is almost infinitesimal, and its attraction on the earth practically *nil*. But a gaseous nebula having the same *apparent* size will have an enormous volume, and, although probably formed of a very tenuous gas, its mass will be very great, and its attractive power very considerable. The large apparent size of the Orion nebula shows that its volume is probably very great, and as its attraction on the sun is not appreciable, its density must be excessively small, probably less than the density of the air remaining in the receiver of the best air pump after the air has been exhausted. How such a tenuous gas can shine as it does forms another paradox. Its light is probably due to some phosphorescent or electrical action.

There is a similar paradox connected with the Milky Way. Taking any portion of it, its apparent area will be inversely proportional to the square of its distance from the earth, and as the light of each of its component stars is reduced in the same proportion, its light will remain constant whatever its distance may be. Hence the brightness of the Milky Way is no test of its distance, as some astronomers have erroneously supposed.

According to Newton's law the force of gravitation varies inversely as the square of the distance from

* Knowledge and Scientific News.

† I. Corinthians, Chap. xv., v. 41.

the center of force. This is found to be true in the solar system, and it also probably holds good in the binary stars. But this is not so in the revolutions of the stars composing a globular cluster round the center of gravity of the cluster, which is probably situated near the center of the sphere. From what Newton has proved about the internal attraction of a homogeneous sphere, it follows that in this case the force will vary *directly as the distance* from the center, and each body composing the cluster (except those at the surface) will revolve round the center of gravity of the whole, the period of revolution of each being the same.*

Another paradox is found in the motions of comets which approach very near the sun at their perihelion passage. Some have actually passed through the sun's corona, or outer envelope. This medium, although highly rarefied, produces a resistance to the motion of a comet in the same way that a meteor passing through the upper regions of the earth's atmosphere has its motion retarded; the lost energy being then converted into heat renders the body incandescent, and causes it to appear as a "shooting star." In the case of a comet one would think that the resisting medium would cause it to move slower, but the reverse of this is the case. The motion is certainly reduced at first, but owing to the diminished velocity the comet approaches nearer to the sun than it would otherwise do. Its orbit is thereby reduced in size, and the velocity is increased. This is a very curious fact, but is undoubtedly true. Encke's comet is an example. Its period (about 1,203 days) is shortening every revolution, and is now about 54 hours shorter than when it was discovered in 1819.

Many of the ordinary phenomena of the heavens are apparently true, although absolutely false, and these may, perhaps, be included among the paradoxes. The sun apparently moves round the earth from east to west in 24 hours, but its real motion is from west to east once in the course of a year. The apparent daily motion is, of course, due to the earth's real rotation on its axis in the opposite direction, and the apparent annual motion is caused by the earth's real revolution round the sun. The sun's apparent motion from east to west is evident to everyone, but its motion from west to east can only be detected by careful observation, and is probably unknown to many educated (or so-called "educated") people. By "careful observation" I do not mean observations with telescopes or astronomical instruments. I mean ordinary observation without any instrumental assistance. The simple fact that the stars set earlier every evening should be sufficient to show any intelligent observer that the sun has an apparent motion from west to east. This fact was known to the ancients 3,000 years ago, but in these days of "higher education" most people's eyes seem—like the man with "the Muck Rake"—to be so fixed on the baubles of earth that they are unable to see anything in the heavens. Similar remarks apply to the moon, but in this case the motion from west to east—which is here a real motion—is obvious.

Another paradox is that the moon seems to be larger when near the horizon than it is when high in the sky. This is merely an optical illusion, for, as a matter of fact, the moon's apparent diameter is actually *less* when near the horizon, as theory requires, and careful measurement proves to be the case.

Many people speak of the earth as "a small place," because they happen to meet their friends at some spa in England, or some resort on the Continent, or elsewhere. But this idea is quite erroneous. Far from being small it is, compared with the size of a man or even a city, immensely large, or, we might even say, inconceivably gigantic. On the other hand, it is, compared with the size of the solar system, very small indeed, and with reference to the Milky Way merely as a grain of sand on the ocean shore. It is, therefore, very large and very small at the same time; very large compared with the objects around us, and very small indeed in comparison with the vast extent of the visible universe.

Another curious paradox is that one can discover an object without seeing it, and see an object without discovering it. The planet Neptune was discovered by Adams and Leverrier by calculations before it was actually seen in the telescope by Galle; and it was actually seen by Lalande on May 8 and 10, 1795, but he took it for a star and thus missed the discovery. In fact, he *saw* the planet, but did not *discover* it. The great new star of 1901 was probably seen by some people before its discovery was announced, and it was actually noticed by a well-known American astronomer, who thought it was some bright star with which he was not familiar. But this did not amount to a discovery. Anyone absolutely ignorant of astronomy might have made the same observation. An object must be identified as new before a discovery can be claimed. Some years ago a well-known Dublin naturalist discovered a spider new to science, and after its discovery he found that it was common in nearly every house in Dublin. But this fact did not detract in the least from the merit of its scientific discovery.

Marchpane (Marzipan or Almond Paste).—*a.* Five hundred parts finely powdered sugar, 500 parts blanched, crushed sweet almonds, 16 parts bitter almonds and sugar, similarly prepared, worked together into a paste, rolled out, etc. *b.* Five hundred parts of sweet almonds, water crushed; 250 parts pulverized sugar, roasted over the fire as long as it can readily be detached from the skillet. Then for each 500 parts of paste, 320 parts of sugar, etc.

* Newton's Principia, Book I., Prop. 89.

ENGINEERING NOTES.

The Pennsylvania Railroad has ordered 200 steel passenger cars to be built by the American Car and Foundry Company, the Pressed Steel Car Company, and the Altoona shops of the Pennsylvania Railroad in the proportion of 95, 80, and 25 respectively. The new cars will be of extraordinary strength and are so-called collision-proof. It is the aim of the company to have all steel passenger cars in service when the New York terminal is completed, and at least 1,000 steel coaches and 500 Pullmans are expected to be in use within a few years.

The first destroyer, "Cossack," for the British navy fitted with turbines has been launched from the shipyards of Cammell, Laird & Co. at Birkenhead, and when completed she will be the largest and fastest ocean-going craft of this type afloat, the contracted speed being 33 knots. At the present time the fastest vessels of this class in the British navy are of 30 knots speed, but those destroyers designed for ocean work attain only 25 knots. The same builders, however, have a second destroyer on their stocks which will exceed the "Cossack" in speed, as the engines are contracted to develop 36 knots.

The Times Engineering Supplement gives some interesting information about the extreme conditions which the hydraulic engineer meets with. At the present time there are turbines working under the enormous effective head of 3,018 feet, and there also are turbines working under a head of only 2 feet. The former is installed at Lake Tanay, and is at present the highest utilized head in the world. In this country there is an installation at Manitou, near Colorado Springs, which works at an effective head of 2,200 feet. The low head plant referred to is driving a mill near Worcester. The turbine is a parallel flow wheel with a vertical shaft, the diameter of the wheel being 13 feet 2 inches. It is made up of two concentric rings of buckets, of which the inner set can be closed to the passage of water, so as to limit the operation of the wheel to the outer ring. As the flow of water in the river is variable, a head of 3 feet in certain periods acts upon the wheel, and the 40 horse-power required to drive the mill is obtained from the outer ring alone, but at other seasons of the year when the fall is reduced to 2 feet and even less, the full capacity of the wheel is utilized. This gives an example of how, in small rivers in which the amount of the discharge of water can be fairly well relied upon, a very moderate head of water may be turned into profitable use. The cost of the turbine installation, excluding the cost of foundations and special work depending on the local conditions, is approximately $150 per horse-power. The chief object of the foregoing remarks is to point out what has been done in utilizing water power under extreme conditions. Each problem, depending as it does on commercial considerations, has to be solved independently, and in some cases it will be found that the cost of the development of the water power precludes the possibility of any advantage over steam power, while in others a waste of natural power may be turned to good use.

One of the main reasons why Germany has in recent years risen to such a supremacy in engineering matters is undoubtedly, to a great extent, the fact that there have been established in that country from time to time various testing laboratories maintained at public expense. These investigate technical problems, and publish the results so as to benefit thereby the greatest possible number of German manufacturers. While there is no doubt that there has been a great deal of experimental work undertaken in this country, these experiments have, with few exceptions, been carried out by private individuals or firms who have jealously guarded the results of their investigations, regarding them as assets in trade and terming them trade secrets. For this reason the same investigations are often carried on in a large number of different establishments, and considering the nation as a whole, a large amount of work is wasted, inasmuch as, if these experiments had been carried on at a general central station, all the various firms would have been equally benefited by the results, with only a fraction of the expense to the nation as a whole. The latest German institution aiming at decreasing the cost of individually conducted experiments is reported to be a large chemical laboratory which will probably be located in the vicinity of Berlin. The initial expense will be $400,000, and the government will probably advance the money needed for keeping the institution working along such lines and in such a way as to give the greatest possible impetus to German chemical industries. The new institution, it is hoped, will work in close co-operation with the factories themselves, and will for industrial purposes supersede the chemical laboratories of the various German universities and colleges, the object of which, it is argued, should be principally educational, and be totally different from that of the contemplated institution which is intended to become the center of chemical research in Germany. It is evident that movements of this kind are far easier to inaugurate in European countries, where there is a strong centralized government considering as its duty to deal with problems of this kind, but there are no doubts that if it would be possible for certain industries in this country to unite and support some kind of a general research laboratory, a great saving would be effected in the long run, and the progress of our industries would be assured in a far greater degree than when individual persons or firms are carrying on their own experiments, often with little or no system.—Machinery.

SCIENCE NOTES.

The destructive pest the fruit-fly, which has wrought such widespread havoc in the fruit-growing sections of India and the south of China, has forced its way into the fruit culture district of New South Wales and Victoria, and is occasioning the farmers considerable concern. The discovery of a means of eradicating this insect is now occupying the earnest attention of both the authorities and the cultivators, since nothing short of complete destruction of the affected orchards appears to be efficient. Spraying has been found to be absolutely useless, as the insect multiplies with amazing rapidity. Mr. George Compere, the government entomologist for Western Australia, has obtained from southern China specimens of the parasite wasp which has proved so beneficial in the affected areas of that country and India, but whether the climatic conditions of the Australian continent will exercise any deterrent influence upon the exterminating possibilities of the wasp remains to be seen.

When we pass along the streets of our cities and large towns and observe the number of persons between the ages of twenty and forty who wear spectacles; or again, if we inspect the eyesight of the children of our public schools and of the young people in our colleges, we find that a large proportion of the present generation is afflicted with visual organs more or less defective. More than this, there is hardly a person over fifty who does not use some sort of artificial aid to sight. In the German universities the situation is still worse. There, apparently, almost one-half of the students wear eye-glasses. England furnishes a marked contrast; spectacles on the eyes of young men and young women are far less common. The chief reason doubtless is the fondness of both sexes for outdoor life. It is highly probable that our somewhat abnormal eyesight is chiefly due to the abnormal conditions under which we live. The epithet *abnormal* is of course to be understood in a relative sense; it is not strictly applicable to a highly developed stage of civilization. It cannot properly be said that the conditions under which the Papuans or the Bushmen live are more natural than those of the residents of London or New York. Each generation is, in a sense, weaker but also wiser; what is lost in one direction is more than made up in another. Still, the injudicious use of the eyes in artificial light and a short range of vision seem to be inevitably imposed upon the dwellers in cities. It is a well-established fact in hygiene that any bodily organ is strengthened by the wise use of it. This being the case, it follows that persons who spend much of their time out-of-doors and in looking at objects afar off, or who use their eyes but little after nightfall, will retain their sight unimpaired much longer than do most people of the present day. On the other hand, failing vision is the natural concomitant of advancing age, so that the number of persons beyond sixty who see clearly with the naked eye is exceedingly small and probably was never very large.—Popular Science Monthly.

Prof. G. E. Hale has recently published an interesting account of a new form of coelostat telescope which he proposes to erect at the Mount Wilson Observatory, the design being arranged to eliminate as far as possible the difficulties encountered in recent work. These have been due chiefly to distortion of the mirrors and local disturbances of the atmosphere caused by the sun's heat, all of which are more serious than are encountered during the course of night observations. An approach to an ideal equipment is outlined, including a coelostat (to insure there being no rotation of the image), mounted at a considerable height above the ground, to reduce the effect of the hot air rising from the ground. The ground about the instrument should be shaded for this same reason. It will be best to arrange the instrument for early morning and late afternoon observations, the former being the most important, because of the better definition at that time. All the mirrors employed should be completely filled with sunlight to avoid irregular distortion, and should be extremely thick, to reduce the amount of bending by the heat of the sun's rays. The beam of light should be vertical, and the image formed by an object-glass rather than a concave mirror. The spectroscopic equipment to be below ground, and all precautions taken to keep the temperature as constant as possible. In carrying out this programme two galvanized steel towers about 60 feet high are to be erected over the mouth of a pit some 30 feet deep. The central tower will carry the coelostat, secondary mirror, and object-glass of 60 feet focal length, and the outer tower is to be incased with canvas louvres to protect the inner one from wind. The mirrors (17 inches diameter and 12 inches thick) are to be silvered on both surfaces, the back being heated by sunlight reflected from other mirrors. From these the light is reflected to the object-glass of 12 inches diameter, giving an image of the sun about 6 inches diameter on the slit plate of the spectroheliograph or Littrow spectroscope below. These instruments are to be provided with objectives of 30 feet focal length. To produce the requisite translatory motion of the solar image the object-glass will be traversed by an electro-motor, which, by suitable gearing, also moves the plate-holder outside the secondary slit, passing K or other monochromatic radiation to the photographic plate. Three slits are to be employed, so that three photographs of the same part of the sun may be taken simultaneously with the aid of three different lines, the comparison of which should prove extremely interesting and instructive. The Littrow spectrograph will contain a plane grating of eight inches aperture, having 500 to

the millimeter, and will be employed for the photographic study of the solar rotation and sunspot spectra.

TRADE NOTES AND FORMULÆ

Anti-Vermin for the Prevention of Noxious Insects in Flower Beds.—2,000 parts by weight of tobacco leaf, cut up, and 3,000 parts of fresh, but not wetted, lupine seeds, over which pour 15,000 parts of water boiling hot. Allow it to stand in the pot for half a day, stir well, and pour off the liquid. To the remaining leaves and seeds add 10,000 parts of boiling water. Allow it to stand over night, pour off the liquid, and press out the residue. Having mixed the two liquid extracts together, add to the fluid 50 parts of borax powder and 10 parts of English, or concentrated, sulphuric acid. Concentrate by boiling in a copper kettle to about 19,000 parts. After cooling, add, stirring vigorously the while, 3 parts oil of cloves, 10 parts of eucalyptus oil, 100 parts of alcohol, and 30 parts of amylic alcohol (fusel oil). Preserve in bottles. Directions for use: 1 part of the mixture mixed with 3 parts of water and the earth sprayed with it after being first raked up.

Bengal Fires.—

	I.	II.
Blue.	Parts.	Parts.
Chlorate of potash	10	10
Nitrate of potash	10	10
Protochloride of copper	5	8
Sulphur	4	7
Solution of shellac	6	6
Golden Yellow.		
Chlorate of soda	10	10
Soda saltpetre	10	10
Oxalate of soda	5	4
Nitrate of potash	10	10
Solution of shellac	5	5
Nitrate of barium	..	2
Green.		
Chlorate of potash	10	10
Chlorate of barium	6	12
Shellac solution	5	5
Red.		
Chlorate of potash	10	10
Nitrate of potash	10	10
Nitrate of strontium	5	10
Shellac solution	5	5

Parts by weight.

Copying Mechanical and Other Drawings.—Copying paper which reproduces the lines of the drawing in white on a dark-blue ground. The drawing is simply spread over the copying paper, held in place by a covering of glass, and exposed for about 10 minutes to the sunlight. Simple washing with clear water fixes the copy. Production: Perchloride of iron, decomposed by ammonia and the oxyhydrate of iron washed out, is dissolved in 3 parts of oxalic acid. In the same manner red prussiate of potash (freshly prepared and free from the yellow prussiate of potash) is dissolved. To 1 part of red prussiate of potash take 3 parts of iron oxide. Two parts of red prussiate of potash and 3 parts of oxalate of iron oxide exactly decompose each other, after the latter has been reduced to ferrous oxide. By preliminary analysis of the chloride of iron solution and weighing the oxalic acid and red prussiate of potash, we obtain the normal solutions. 31.7 parts of red prussiate of potash are dissolved to make 500 parts of solution. The perchloride of iron solution contains 2.8 parts of iron in 50 parts. For the solution of the iron oxide precipitated from this volume, weigh out 9.45 parts of crystallized oxalic acid, and the solution produced with it is also brought up to 500 parts. 300 parts of the iron solution and 100 parts of the red prussiate of potash solution are mixed. The entire process is carried out by daylight; the paper steeped in the mixture, dried, and exposed, under a line drawing, to the sunlight.

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